



INTERNATIONAL SCIENTIFIC CONFERENCE ON INFORMATION TECHNOLOGY, COMPUTER SCIENCE, AND DATA SCIENCE



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SINTEZA 2023

ABOUT SINTEZA 2023

The 10th jubilee international scientific conference Sinteza was held on May 27, 2023, and it was organised in a hybrid mode - at Singidunum University premises and online. The conference was dedicated to information technology, computer sciences, data science and their application in engineering systems, education, teaching foreign languages, sports, marketing, ecology, medicine, and pharmacy. This year conference topics of particular interest have been related to artificial intelligence, machine learning and data research, and their application in solving real-world problems.

The conference once again brought together researchers from the country and abroad. A total of 63 works were submitted, 46 of which were accepted. All accepted papers have passed technical, language, and content reviews, as well as the iThenticate check. The authors came from 9 countries including Serbia.

At the plenary, six keynote speakers from the United States of America, Austria, the Russian Federation, Turkey, and Serbia presented their research and project work and findings that were predominantly in the field of information technology and artificial intelligence. Various topics, such as trends in artificial intelligence, the application of machine learning in different industries, and ethical issues related to artificial intelligence, were presented. After the plenary session, the conference continued with 6 parallel sessions: Computer Science and Artificial Intelligence, Information Technology, Advanced Technologies and Applications, Applied Information Technology, Information Technology in Sports and Information Technology in Foreign Language Teaching. The parallel sessions were interactive and dynamic, providing the presenters with the opportunity to present their research papers, case studies, and innovative projects, and the conference participants with the opportunity to discuss relevant issues and receive feedback from experts in their field.

We would like to thank the esteemed speakers at the plenary session, all conference participants, and the members of the Scientific Committee. We would like to express our special gratitude to the colleagues from the Organizing Committee who technically prepared and supported the organization of the Sinteza 2023 conference.

Sincerely, Sinteza 2023 Organising Committee



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CONTENTS

COMPUTER SCIENCE AND ARTIFICIAL INTELLIGENCE SESSION

CHAIRMAN: Nebojša Bačanin Džakula

2 - 8	APPLICATION OF MACHINE LEARNING TO HIGH-REPETITION-RATE LASER-PLASMA PHYSICS ON THE PATH TO INERTIAL FUSION ENERGY Blagoje Đorđević, P.T. Bremer, G.J. Williams, T. Ma, D.A. Mariscal
9 - 16	STYLE ADAPTATION BASED ON IMAGE PROCESSING METHODS Branisav Popović
17 - 22	REVEALING TOLUENE BEHAVIOUR IN THE ATMOSPHERE BASED ON COUPLING OF METAHEURISTICS, XGBOOST, AND SHAP Gordana Jovanović, Mirjana Perišić, Svetlana Stanišić, Nebojša Bačanin Džakula, Andreja Stojić
23 - 27	IMITATION DRAWING: CAN WE SPOT THE DIFFERENCE BETWEEN AI AND HUMAN GENERATED DRAWING? Milić Vukojičić, Jovana Krstić, Mladen Veinović
28 - 35	GENERATIVE ARTIFICIAL INTELLIGENCE FOR RETINAL DEGENERATION: A REVIEW Fakhra Riaz, Samina Khalid, Muhammad Fahad Latif
36 - 43	NEXT-GENERATION FIREWALL AND ARTIFICIAL INTELLIGENCE Aleksandar Jokić, Marko Šarac, Saša Adamović
44 - 51	HEAT FLOW PROCESS IDENTIFICATION USING ANFIS – GA MODEL Mitra Vesović, Radiša Jovanović
52 - 59	APPLICATION OF CONVOLUTIONAL NEURAL NETWORKS FOR THE CLASSIFICATION OF HUMAN EMOTIONS Nikola Matijašević, Andreja Samčović, Marko Đogatović
60 - 65	THE USE OF COMPUTER VISION IN PRECISION AGRICULTURE Vesna Radojčić, Aleksandar Sandro Cvetković, Miloš Dobrojević





INFORMATION TECHNOLOGY SESSION

CHAIRMAN: Mlađan Jovanović

68 - 75	MEASURING INFORMATION APPLICATION FOR ACTIVITY IN SYSTEMS SUCCESS Alexander S. Geyda, Svyatoslav A. Derzhavin
76 - 84	BAB (BUSINESS APPLICATION BUILDER) FRAMEWORK FOR RAPID DEVELOPMENT OF BUSINESS INFORMATION SYSTEMS Borivoj Bogdanović, Zora Konjović, Đorđe Obradović
85 - 93	EHEALTHCARE SECURITY CONCEPT BASED ON PKI AND BLOCKCHAIN TECHNOLOGY Dejan Cizelj, Tomislav Unkašević, Zoran Banjac
94 - 99	CREATION OF STRUCTURED FORMATTED DATABASE FOR ALUMNI PROJECT Đorđe Dihovični, Dragan Kreculj, Nada Ratković Kovačević, Petar Jakovljević
100 - 104	MONOCULAR DEPTH ESTIMATION USING STATE-OF-THE-ART ALGORITHMS: A REVIEW Tea Dogandžić, Anđela Jovanović
105 - 109	APPLICATION OF THE MS EXCEL ON NUMERICAL SOLVING OF ORDINARY DIFFERENTIAL EQUATIONS Duško Salemović, Tanja Sekulić, Ninoslava Tihi, Biljana Maljugić
110 - 115	POLITICAL COMMUNICATION IN SERBIA – DIGITAL VERSUS TRADITIONAL MEDIA Aleksandra Belačić, Slavko Alčaković
116 -123	FUNCTOR AND APPLICATIVE FUNCTOR USAGE IN TYPESCRIPT Matija Matović, Milan Segedinac
124 - 131	APPLICATION OF COMPUTER NETWORK SIMULATION SOFTWARE IN VIRTUAL ENVIRONMENT Ana Bašić, Dragan Rastovac, Dejan Viduka
132 - 137	PFSENSE ROUTER AND FIREWALL SOFTWARE Dragan Kreculj, Đorđe Dihovični, Nada Ratković Kovačević, Maja Gaborov, Marija Zajeganović





ADVANCED TECHNOLOGIES AND APPLICATIONS SESSION

CHAIRMAN: Marko Tanasković

140 - 146	MATHEMATICAL MODELING AND FILE SYSTEM PERFORMANCE EXAMINATION FOR TYPE 1 HYPERVISOR WITH FULL HARDWARE VIRTUALIZATION IN THE CASE OF KVM AND MS HYPER-V Borislav Đorđević, Nenad Kraljević, Svetlana Štrbac-Savić, Nenad Korolija
147 - 152	THE IMPACT OF JOB AUTOMATION ON MEN AND WOMEN IN THE DIGITAL AGE Jelena Lukić Nikolić, Vladimir Mirković
153 - 158	THE MAIN CONCERNS OF EMPLOYED PEOPLE REGARDING ROBOTS AT WORKPLACE IN THE DIGITAL AGE Jelena Lukić Nikolić, Vladimir Mirković
159 - 165	SCRATCHPAD MEMORY UNIT IN HYBRID CONTROL-FLOW AND DATAFLOW ARCHITECTURES Nenad Korolija, Svetlana Štrbac-Savić, Borislav Đorđević
166 - 171	APPLICATION OF THE 3D GEOGEBRA CALCULATOR FOR TEACHING AND LEARNING STEREOMETRY Tanja Sekulić, Goran Manigoda, Valentina Kostić
172 - 177	MODELING INTERNET TRAFFIC PACKET LENGTH USING PROBDISTID: A CASE STUDY Dragiša Miljković, Siniša Ilić, Branimir Jakšić, Petar Milić, Stefan Pitulić







APPLIED INFORMATION TECHNOLOGY SESSION

CHAIRMAN: Miodrag Živković

180 - 184	ADVANCED TECHNOLOGIES AS A FRAMEWORK FOR SUSTAINABLE MARKETING CAMPAIGNS (AI APPLICATION IN NEUROMARKETING) Papić Tamara, Mihajlović Aleksandar, Gajić Jelena
185 - 190	WEB APPLICATION FOR DISPLAYING RESULTS OF AIR QUALITY MEASUREMENT USING VIEW PLUS RADON DETECTORT Željko Eremić, Iris Borjanović
191 - 198	THE ROLE OF SOCIAL NETWORKS IN THE COMMUNICATION OF MEDICAL DOCTORS DURING COVID-19 PANDEMIC Alexios-Serafeim Nterekas, Christos Dr. Melas, Georgia Ntereka, Vassilis S. Moustakis
199 - 205	CREATING AN EDUCATIONAL FRAMEWORK FOR PROJECT MANAGERS AT A SOFTWARE COMPANY: A SAMPLE APPROACH Srđan Atanasijević, Monika Zahar, Dejan Rančić, Tatjana Atanasijević, Milan Đorđević
206 - 213	MODEL FOR PERSONALIZATION OF SALES PROMOTIONS BASED ON BEACON TECHNOLOGY Ivana Stefanović, Snežana Mladenović, Slađana Janković, Ana Uzelac
214 - 219	COMPARATIVE STUDY OF THREE METHODS FOR BRAIN TUMOR DETECTION AND EXTRACTION USING IMAGE SEGMENTATION TECHNIQUES Jelena Cerovina, Predrag Lekić, Mirko Milošević, Petar Spalević, Mile Petrović
220 - 226	A NOTE ON VEHICLE-TO-GRID SIMULATION FOR A SMART MICROGRID Dürdane Yıldırım, Cemal Keleş
227 - 234	AUTOMATIC ROAD EXTRACTION AND VECTORIZATION FROM SCANNED TOPOGRAPHIC MAPS Marko Mrlješ, Miloš Basarić, Saša Bakrač, Stevan Radojčić
235 - 241	ROBOT MOVEMENT PROGRAMMING FOR FLEXIBLE CELL IN "OPEN CIM SCREEN" Petar Jakovljević, Đorđe Dihovični, Nada Ratković Kovačević





INFORMATION TECHNOLOGY IN SPORTS SESSION

CHAIRMAN: Srđan Marković

244 - 250	SPONSORSHIP APPLICATIONS IN DIGITAL SPORTS MARKETING Özge Ercan
251 - 258	PSYCHOMETRIC PROPERTIES OF ONLINE VERSIONS OF MENTAL TOUGHNESS QUESTIONNAIRES IN BASKETBALL PLAYERS Petar Šešlija, Nenad Trunić, Srđan Marković, Jovana Popović, Miloš Milošević
259 - 266	PSYCHOMETRIC PROPERTIES OF ONLINE VERSIONS OF EMPATHY AND DARK TRIAD PERSONALITY TRAITS QUESTIONNAIRES IN BASKETBALL PLAYERS Petar Šešlija, Nenad Trunić, Srđan Marković, Jovana Popović, Miloš Milošević
267 - 271	TRACKING OF THE RELEVANT FITNESS PARAMETERS IN YOUNGBASKETBALL PLAYERS Aleksandar Gadžić, Nenad Trunić, Aleksandar Živković, Dušan Nikolić



INFORMATION TECHNOLOGY IN TEACHING FOREIGN LANGUAGES SESSION

CHAIRMAN: Valentina Gavranović

274 - 280	USING MOODLE IN EFL TEACHING IN ITALY: THE CASE OF EVERYWHERE Michael Boyd, Fabrizio Gallai
281 - 287	DIGITAL TOOLS FOR LANGUAGE LEARNING: EXPLORING TEACHERS' INNOVATIVE AND ENGAGING PRACTICES
	Aleksandra Gagić, Tijana Gajić, Valentina Gavranović, Neda Maenza, Maja Veljković Michos
288 - 293	CHALLENGES OF TRANSLATION RELIABILITY IN THE ERA OF TRANSLATION TOOLS: ANALYSIS OF TRANSLATIONS FROM THE SERBIAN LANGUAGE
	Miloš Pupavac, Maja Rončević, Neda Maenza, Jovan Travica, Georgios Nektarios Lois
294 - 298	DIGIDAZU - A PORTAL FOR LEARNING THE GERMAN LANGUAGE IN A BUSINESS DIGITAL ENVIRONMENT
	Magdalena Duvnjak, Jovan Travica, Katarina Nasradin, Maja Rončević
299 - 305	FLIPPED CLASSROOM: PROMOTING ACTIVE LSP TEACHING AND LEARNING Maja Veljković Michos, Margarita Robles Gómez
306 - 311	USING AI CHATBOTS IN ACADEMIA- THE OPINIONS OF UNIVERSITY STUDENTS Nina Pantelić, Miloš Milošević, Valentina Bošković Marković
312 - 319	AMERICAN SIGN LANGUAGE ALPHABET RECOGNITION AND TRANSLATION Nenad Panić
320 - 326	TEACHERS' PERCEPTIONS OF ICT IN POST-PANDEMIC FOREIGN LANGUAGE TEACHING AT THE TERTIARY LEVEL IN SERBIA Milica Popović





SINTEZA 2023 INTERNATIONAL SCIENTIFIC CONFERENCE ON INFORMATION TECHNOLOGY, COMPUTER SCIENCE, AND DATA SCIENCE

COMPUTER SCIENCE AND ARTIFICIAL INTELLIGENCE SESSION INVITED PAPER

APPLICATION OF MACHINE LEARNING TO HIGH-REPETITION-RATE LASER-PLASMA PHYSICS ON THE PATH TO INERTIAL FUSION ENERGY

Blagoje Đorđević*, P.-T. Bremer, G.J. Williams, T. Ma, D.A. Mariscal

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Abstract:

One of the grand challenges of the plasma physics community is mastering controlled nuclear fusion as an energy source, with one approach being inertial confinement fusion (ICF). ICF is an extremely complex scientific and engineering problem that spans many physical regimes and requires precise control of the system over many orders of magnitude in space and time. Recent scientific achievements have raised our confidence in the feasibility of this goal, but much work remains to make inertial fusion energy a reality. An important research thrust has been the implementation of machine learning on ICF and specifically on the high-repetition-rate laser systems needed to make fusion energy practical. With an eye to technology transfer, there has been work attempting to operate, understand, and control of HRRLs on smaller laser-plasma experiments and associated modeling efforts. Presented here will be a series of examples of how machine learning is applied to these topics at LLNL.

Keywords:

Inertial Confinement Fusion, Machine Learning, Plasma Physics, Lasers, Nuclear Energy.

INTRODUCTION

Nuclear fusion is the process that powers the stars and harnessing it for inertial confinement energy (IFE) has been a goal of the physics community for over 60 years [1]-[4]. Until recently, the goal of energy breakeven remained elusive for the field of inertial confinement fusion (ICF) and high-energy-density (HED) plasma physics [5], [6]. However, on December 4th, 2022, the National Ignition Facility (NIF) at Lawrence Livermore National Laboratory (LLNL) achieved breakeven, where 2.05 megajoules of laser energy was delivered onto the target and 3.15 megajoules of fusion energy output was generated. This breakthrough entailed a scientific gain of Q_s=1.5 and has heralded a renewal of interest in fusion energy. Here the lasers cause a capsule of deuterium and tritium (DT) to compress into a ball of burning plasma, converting mass into energy, visualized in Figure 1. However, there is much work to be done before this can become an energy source. A critical hurdle is that NIF typically is only able to fire once a day, while to generate enough energy to be useful for electricity we need ~10 Hz operations. So, to achieve a viable energy source, we need to develop and optimize high-repetition-rate laser (HRRL) systems.

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Figure 1 - The process of achieving nuclear fusion at NIF [4], [7], produced by J. Lett.

Managing NIF systems safely and precisely requires great expenditure and effort. This becomes exponentially more challenging when we wish to not only elevate the gain of our systems 100 times but also to increase the rate of operations 1,000,000-fold. To address this challenge, resources have been devoted to applying machine learning (ML) to fusion research. ML has experienced a renaissance during the past decade with the development of deep neural networks (NNs) and the advent of relatively cheap GPU technology. There has been great interest in applying ML to ICF in recent years, such as developing surrogate models of expensive simulations and experiments, identifying optical defects, and suggesting new configurations to optimize performance.

Since its inception, the ICF community has been deeply involved in advanced computational methods and technologies and LLNL and the general HED community have been taking advantage of advances in ML. Artificial Intelligence and ML are being pursued to help design targets, interpret diagnostics, analyze experiments, and improve simulation predictions. ML can accelerate the rate of learning in tandem with HRRL systems in ways not previously possible [8]. Surrogate models of sub-physics models and entire simulations allow for rapid investigation of wide parameter spaces for design. ML may also offer a new way to bridge physical regimes, as ICF covers many orders of magnitude. A common approach to ML at LLNL is to generate large ensembles of simulation results leveraging the supercomputing capabilities available [9], [10], [11], as NNs are data-intensive.

2. LASER TECHNOLOGY

Current ICF laser systems operate once a day and are constrained not only by drive sourcing but also by safety concerns. In one study a convolutional neural network (CNN) was trained on the input and output spectra of a 1-D physical model of the laser amplification process and classified the output spectra into safe/unsafe categories [12]. The CNN model achieved 98% accuracy on this binary classification problem. In a similar context, a Bayesian CNN model was used [13], which follows the architecture presented in Ref. [14], whereby a dropout layer is added before each layer and allows for probabilistic inference. An active learning training procedure was used, which incrementally selects the most informative data instances to be included in training. This allows for quicker convergence than training a regular CNN model. A common problem for HRRL systems is drift, where the laser pointing and performance change over time. To account for this the CNN model was exposed to multiple datasets in a sequential manner. One of the most desirable traits of NN-based surrogate models is their relative speed of deployment after they have been trained.



Figure 2 - (left) Sample of output power spectrum of an amplifier predicted by machine learning (blue) and 1D physical model (red). (center) Accuracy of damage risk as a function of the number of training data for regular (red) and active learning (blue). (right) Damage risk factor predicted by the model when trained during system drift. Reproduced from [12], with permission of Optica Publishing.

It is expected that in an IFE system, where diagnostic analysis and software would be encoded into surrogates generated via mL that allow for rapid analysis and control of the IFE operation loop. We are currently prototyping such techniques on smaller HRRL systems as described here.

Before every shot, NIF performs extensive maintenance of the optical systems that generate and deliver the lasers to the target capsule. High-fluence lasers slowly chip away at the lenses and mirrors in the laser chain. Damage sites are removed but sometimes microscopic sub-surface cracks remain that can easily grow when exposed to the high thermal stresses of the laser. In Ref. [15], a network was developed that was able to identify optical defects more rapidly and accurately than a human expert. In this case they took pre-trained, publicly available networks such as AlexNet [16] and ResNet [17] with more than 20,000 categories [18]. These networks were not trained on optical defects, but the intuition built into them allowed them to easily learn the features present in the NIF optics dataset of only 2,813 truthlabeled images.

3. INERTIAL CONFINEMENT FUSION

An early example of ML and ICF involved approximately 4,000 2D HYDRA simulations of the capsule implosion selected with Latin hyper-cube sampling [19]. This study focused on the consequences of drive asymmetry, which is a perennial problem in ICF. Drive asymmetries lead to less efficient compression and may cause ignition to fail, due to hydrodynamic instabilities which pierce and cool the central hotspot. Using this data, a Gaussian Process (GP) surrogate model was trained on capsule properties, total neutron yield, and yield-overclean, a ratio comparing a perturbed capsule implosion to a perfectly symmetrical one. Training studies found that 2,500 simulations or more resulted in a R²>0.95. GP models are advantageous because they can give us statistically meaningful uncertainties, but do not scale as well with large datasets and dimensionality as other techniques.

Another study used a supervised ML algorithm trained on petabytes of ICF simulation data, with 60,000 2D capsule simulations, to identify a class of ICF implosions that are more robust to perturbations [20]. As opposed to a GP model, this study used a random forest model, which can handle large quantities of data and readily incorporate nonlinearities, which is important as we are looking for cliffs in the parameter space. To rapidly find the optimum in the simulation parameter space the Nelder-Mead simplex-based optimization routine was used [21]. The optimization algorithm, using rapid surrogate calls in lieu of direct simulations, identified an ovoid shape for the capsule to be more robust to perturbations of the total drive fluence. The discovered ovoid shape and the output yield of a baseline, spherical capsule versus an ovoid are shown in Figure 3. While the baseline, spherical capsule reaches high yields for a wider range of drive fluences, the ovoid is more robust to P1 mode asymmetry perturbations. It was concluded that coherent flows in the hot spot can stabilize shell deformations that may arise during stagnation. Such surrogate modeling work has continued with the application of NNs, e.g., transfer learning between different types of fidelity of ICF data [22] and uncertainty quantification [23].

Also, of great interest in ICF is how data can be condensed and represented in lower dimensional spaces. In Ref. [24] was introduced the concept of a manifold and cyclically consistent (MaCC) surrogate that uses a multi-modal and self-consistent NN that outperforms many other state-of-the-art models. The autoencoder structure approximates multimodal data and finds the optimal representation of it in the lowest-dimensional layer of the autoencoder, which we call the latent space.



Figure 3 - (left) Velocity (arrows), density (gray), ion temperature (left color contours), and pressure (right color contours) at the time of peak energy production for an ovoid implosion. (right) The surrogate's estimate of yield under changing total drive fluence for the baseline (round) and optimal (ovoid) cases. Reproduced from [20], with the permission of AIP publishing.

An inverse network trains in parallel with the surrogate model and cyclical consistency between the two acts as a regularization factor in an unsupervised fashion. The architecture was deployed on ICF datasets, specifically, scalars of note such as the yield and images of artificial diagnostic images of the neutron and X-ray emissions of the capsule implosion. ICF is a challenging subject to model and learn in ML contexts, data is sparsely sampled and highly nonlinear, and the development of advanced techniques such as MaCC will help the development of high-performing surrogate models.

4. LASER-PLASMA PHYSICS

Much effort and thought are dedicated directly to ICF by laser-plasma physicists, but there are several related research topics that synergize with the scientific and technological needs of ICF. A primary example is short-pulse, laser-plasma physics, where physical concepts and engineering constraints are shared. This has been the primary scientific focus of high-power, HRRL systems at LLNL [8]. Laser-plasma experiments, particularly laser-solid interactions, are inherently challenging. The advent of HRRL systems means that experiments often outrun our ability to not only analyze results but also to control and guide them. ML has been deemed as a necessary tool which allows our goals to align with the technical capabilities at hand.

Analogous to work in ICF, work was done applying ML to ensembles of particle-in-cell (PIC) simulations modeling laser-solid interactions. Initial efforts involved generating 1,400 1D PIC simulations which were used as the training set for NNs [25]. A fully connected NN was trained on scalar quantities of interest from the PIC-generated dataset, particularly the particle distributions as seen in Figure 4. In addition to hot electrons, a useful quantity of interest is the maximum ion energy, which following a self-similar model takes the form of

$$E_{max} = 2T_{h} \log \left[t_{p} + \left(t_{p}^{2} + 1 \right)^{\frac{1}{2}} \right]^{2}$$

Equation 1 – Maximum ion energy from self-similar plasma expansion into a vacuum [26].

where T_h is the hot electron temperature, and t_p is the normalized time with respect to the plasma [26].

$$T_{h} \gg m_{e}c^{2}\left(\sqrt{1+7.3\times10^{-19}\left(\lambda\left[\mu m\right]\right)^{2}I_{o}[W/cm^{2}]-1}\right)$$

Equation 2 – Hot electron temperature from ponderomotive scaling of laser-plasma interaction [27].

is quasi-empirical but roughly shows the dependence of hot electrons on intensity and wavelength [27].

The NN can accurately reproduce the scalar quantities of interest and uncertainties were derived by taking a weighted average of a bundle of NNs, where the weighting was proportional to the average inverse loss of the NN at the end of its training [28]. An important quantity in laser-plasma physics is the preplasma, which is the exponential foot of the plasma generated by the low-intensity prepulse of the laser, depicted in Figure 4(left). Given the fast speed of a forward NN, we can use it for inverse modeling. Looking at a small collection of experimental data, we used our NN surrogate model, guided by a genetic algorithm, to estimate what the preplasma might be in those experiments. ML-trained surrogate models as such have been deployed in experiments during operations, allowing us to get live estimates of the experimental results using simulation and prior experimental data. To alleviate data sparsity, we focused on leveraging the transfer learning technique [29] to make our small, sparse datasets more robust. A preliminary effort used tens of thousands of analytical results to pretrain a composite NN architecture [30]. The NN was then retrained on the previous PIC dataset, resulting in greater performance.

Given our initial experience with ensemble simulations and ML, we generated a new dataset of PIC simulations that more closely approximated our experiments at the CSU ALEPH facility, consisting of 8,000 1D PIC simulations and approximately 500 2D simulations [31]. This work came at great computational cost, approximately three million process hours to generate the 1D dataset but two million for the 2D dataset. However, presupposing a hierarchical training framework [29], where we trained on different fidelities, we were able to keep costs within scope, and by transfer learning we were able to train surrogate models on 2D data with relatively high confidence. As an application of the higherfidelity NN we did a parameter scan of laser properties over constant energy surfaces, i.e., $E \propto I_0 \tau r_0^2$, varying from 1 joule to 4 Joules, depicted in Figure 5. The peak ion energy shifts from the long-pulse, low-intensity corner of parameter space for 1 joule to the short-pulse, high-intensity corner at 4 joules. More interestingly, at 2 joules we see a plateau in the long-pulse corner of parameter space. For HRRL applications, such as IFE, this is desirable as it represents a configuration more robust to perturbations, as laser alignment and pointing are not trivial matters. Laser delivery and control typically operate within error-bars of several percent at NIF, where an entire day or more may be spent by a team recalibrating the optics. At HRRL scales we have found such precision to be impossible with current technology and techniques and are looking to ML to assist with that.



Figure 4 - (left) Setup of laser-solid interaction. (right) Phase space of electrons and ions after laser arrival. Reproduced from [25], with the permission of AIP publishing.



Figure 5 - Mapping of ion energy utilizing the transfer-learning-based 2D surrogate model. Each heatmap represents a constant energy surface within the parameter space. Reproduced from [29], with the permission of AIP publishing.

Of particular interest are the particle energy spectra, which are one of the primary observables in HRR experiments. A 1D CNN autoencoder was trained on energy spectra from the 1D dataset and then utilized in several different ways. First, the encoder was coupled to a fully connected NN (FCNN) to predict scalar quantities, such as the hot electron temperature from the energy spectrum. Second, the encoder was frozen and the autoencoder was retrained on the smaller 2D dataset, allowing us to effectively convert 1D predictions to 2D. Lastly, the decoder was spliced to a FCNN for inputs, but with two branches, where the whole network was trained on the 1D dataset and then again on the 2D dataset with 1D input quantities frozen. These are shown in Figure 6. Similar work has been applied on the experimental side, again focusing on particle spectra. In one effort, a CNN was trained first on simulation spectra and correlated to a labelled hot electron temperature [32]. If the CNN was trained directly on the experimental the predictions showed a pronounced bias, plotted as open circles in Figure 7(a). However, if transfer learning was used first, then the NN was able to perform much better (closed circles). Synthetic data generation and subsequent training were also applied to ion diagnostics of greater complexity, where a 2D image simulating an ion beam passing through layered radiochromic film stacks allows us to infer the temporal and spatial distribution of the beam [33].



Figure 6 - Demonstration of how autoencoders can be applied to spectral data from PIC simulations. Reproduced from [29], with the permission of AIP publishing.



Figure 7 - (left) Calibration plot of the predicted electron temperatures using transfer learning. (right) CNN-based architecture used to correlate diagnostic images with scalar parameters of interest. Figures reproduced from [32] and [33], with permission of AIP publishing.

This image is passed through a CNN for data reduction and then given to a FCNN to predict the associated scalar values, as seen in Figure 8(b). Similar work using PCA for data reduction coupled to NNs has been applied to X-ray spectra relevant to ICF and laser-plasma physics [34]. Elevating the idealized results from simulations to our experimental observations is a primary goal in our community, although this is balanced by the significant uncertainties of experimental observables, which will need to be addressed if modeling, diagnostics, and control of IFE laser-plasma systems are to succeed.

5. CONCLUSION

IFE is a challenging goal for the physics community that likely remains many years away. However, given recent successes in ICF, the community has been inspired to redouble its efforts and ML promises to help alleviate many issues. In this manuscript, we have reviewed how ML has been applied to IFE-relevant fields at LLNL, specifically laser technology, ICF, and basic laser-plasma physics. In fact, this is only a small sampling of how ML is being applied to scientific and engineering research at LLNL. With respect to the topics discussed, several upcoming projects are being pursued: adaptive, timedependent laser system controls to address persistent issues in consistency; application of external structures to ICF capsules and numerical optimizing them to enhance implosion yield; and advanced networks architectures for synthesizing non-congruent datasets in the context of shaped, short-pulse laser-solid interactions. Much work is still needed to be done but ML has demonstrated its ability to accelerate the way we do science and will bring the reality of controlled nuclear fusion energy closer.

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SINTEZA 2023

COMPUTER SCIENCE AND ARTIFICIAL INTELLIGENCE SESSION INVITED PAPER

STYLE ADAPTATION BASED ON IMAGE PROCESSING METHODS USING CYCLEGAN

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Abstract:

Cycle-Consistent Generative Adversarial Networks (CycleGANs) are able to provide a highly under-constrained mapping between input and output data samples, i.e., source and target data domain, in cases when the aligned dataset is unavailable, in an unsupervised training fashion, using cycle-consistency loss mechanisms. On the other hand, most image-to-image and speech-to-speech translation tasks use the aligned, i.e., paired input-output training datasets. A large amount of data is necessary to train such architectures, while one of the domains could be scarce.

Several possible improvements to the original CycleGAN architecture are analysed in this paper for the cases when only a small percentage of training samples are aligned among source and target data domains. A semi-supervised approach is proposed to achieve better translation accuracy and prevent overfitting of the scarce data domain discriminator during initial training iterations. The training database is augmented by adding samples generated by inverse CycleGAN mappings after several training epochs (when the network is sufficiently trained) into the training pool of the discriminator of scarce, i.e., reduced data domain. An additional optimization constraint is also proposed, aligning probability distributions of feature maps belonging to the same-depth neural network layers of direct GAN encoder and inverse GAN decoder, to reinforce resemblance among object representations in various data domains.

Significantly better performances are obtained using proposed improvements in both image-to-image and speech-to-speech translation tasks, by observing standard qualitative and quantitative measures, in comparison to the baseline CycleGAN training approach.

Keywords:

Style Adaptation, Generative Adversarial Networks, Cycle-Consistency, Semi-Supervised Learning, Bootstrapping.

INTRODUCTION

Style transfer is a machine-learning technique presuming the translation of a particular referent style (e.g., painting technique, seasonal landscape features, colour schemes, etc. in case of images [1], or speaker characteristics, speaker emotion, pronunciation style, prosody, etc. in case of speech [2]) from one data sample to another (source to target domain), preserving at the same time the core attributes (content, structural features, semantics) of the original sample. Supervised learning methods use pairs of training data samples to be able to learn a one-direction

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e-mail: bpopovic@uns.ac.rs sample-to-sample mapping among samples containing the same structural information. Many of those methods have originated from the conditional GAN (cGAN) training method [3], able to incorporate supplementary information (e.g., class labels), learning the difference between any two particular samples presenting the same entity in various domains.

Pix2Pix training architecture represents a fullysupervised cGAN-based training strategy comprising a U-Net-based generator [4] and a convolutional Patch-GAN discriminator [5] able to cope with an extensive range of image-to-image translation tasks. Pix2Pix operates on real data in conjunction with labels in order to acquire mapping from the source to the target domain along with the reconstruction loss function, using pairs of one-to-one corresponding image representations from both domains. Albeit highly efficient, Pix2Pix cannot easily capture complex scene structural correlations using a single mapping, i.e., a single translation network (one generator and one discriminator). Furthermore, it is often difficult to aggregate a sufficient quantity of paired domain-to-domain training data to be able to train the network assuming appropriate precision and robustness. The latter is also a drawback of other supervised learning methods, such as DRPAN [6], ASAPNet [7] and SPADE [8].

Unsupervised learning methods, such as CycleGAN [9], CoGAN [10], DiscoGAN [11] or UNIT [12], learn corresponding mappings using sets of unaligned training samples from source and target domains (commonly highly under-constrained one-to-many-approach). CycleGAN employs two GANs working in opposite directions (each one has one generator and one discriminator able to provide mappings from source to target domain and back), and a cycle-consistency loss combined with adversarial loss, imposing bijection (mappings become reverses of each other by enforcing structural similarity between the original, i.e., source, and translated data samples after both forward and backward procedures have been completed). However, CycleGANs are unable to perform complex geometrical transformations and they are prone to diminish gradient issues and other types of instabilities, e.g., there are observable disparities in performances of the supervised (trained using pairs of one-to-one corresponding data samples) and the unsupervised version (trained using unaligned data).

Triggered as a result of a deficient number of structurally correlated samples between the source and the target domain (in the case when one of the domains is scarce), a bootstrapped semi-supervised BTS SSL CycleGAN algorithm is proposed [1]. Semi-supervised learning (SSL) strategy exploits the advantage of having a certain percentage of the aligned data samples in the training database to increase the accuracy and improve the overall performance of the CycleGAN algorithm, and at the same time prevents overfitting of both generator and discriminator related to the scarce domain using the rest of data in an unsupervised manner. The second step presumes periodical insertion (i.e., bootstrapping) of samples artificially produced by the generator related to the fully observable domain to the original training pool of the discriminator representing the scarce domain, but only after several training iterations have already been completed (the generator is adequately trained).

Feature Map Regularised FMR CycleGAN approach [13] adds an additional cycle-consistency loss to the objective function. The loss is calculated between probability density functions (PDFs) representing feature-map statistics of the same-depth neural network layers of the direct GAN encoder and the inverse GAN decoder to increase similarity among the original and fully transformed (i.e., passed through forward and backward cycles) features. Starting from the assumption that the PDFs could be observed as Gaussians embedded into the cone of the symmetric positive definite (SPD) matrices, various statistics-based as well as geodesic-ground-distance-based measures can be utilised as a part of the objective function within the training procedure.

Both BTS SLL CycleGAN and FMR CycleGAN models could be employed independently for a multitude of domain-specific style adaptation tasks, such as image-toimage translation or speech enhancement analysed in this paper, the first one requiring only a small number of the aligned data samples during initial training epochs. Baseline CycleGAN architecture is briefly described in Section 2. BTS SSL CycleGAN is presented in Section 3, and FMR CycleGAN in Section 4. In Section 5, experimental results are presented for a variety of image-to-image translation tasks and a speech enhancement, i.e., noise reduction task. Conclusions are drawn in Section 6.

2. CYCLEGAN (BASELINE APPROACH)

CycleGAN [9] is an unsupervised training approach aiming to learn a translation of samples from the originating domain X into a target domain Y. The architecture consists of two generators, $G_{X \rightarrow Y}$ (direct) and $G_{Y \rightarrow X}$ (inverse), and the associated adversarial discriminators, D_X and D_Y . The idea behind the adversarial loss is relatively simple. The generators $G_{X \rightarrow Y}$ and $G_{Y \rightarrow X}$, stimulated by discriminators D_X and D_Y , attempt to minimise the difference between $G_{X \rightarrow Y}(x)$ and y, as well as $G_{Y \rightarrow X}(y)$ and $x, x \in X, y \in Y$, i.e., $G_{X \rightarrow Y}(x)$ should be as close as possible to y and $G_{Y \rightarrow X}(y)$ should be as close as possible to x, while discriminators D_X and D_Y try to distinguish between real (x, y) and translated samples $(G_{Y \rightarrow X}(y), G_{X \rightarrow Y}(x))$.

The adversarial objectives (1) and (2)

$$\mathcal{L}_{adv}(G_{X \to Y}, D_Y) = \mathbb{E}_{y \sim p_Y(y)} [\ln D_Y(y)] + \mathbb{E}_{x \sim p_X(x)} \left[\ln \left(1 - D_Y \big(G_{X \to Y}(x) \big) \right) \right] (1) \mathcal{L}_{adv}(G_{Y \to X}, D_X) = \mathbb{E}_{x \sim p_X(x)} [\ln D_X(x)] + \mathbb{E}_{y \sim p_Y(y)} \left[\ln \left(1 - D_X \big(G_{Y \to X}(y) \big) \right) \right] (2)$$

Equation 1 – Adversarial objectives.

where $p_x(x)$ and $p_y(y)$ represent source and target data distributions, are additionally coupled with forward and backward cycle-consistency objectives, given by

$$\mathcal{L}_{cyc}(G_{X \to Y}, G_{Y \to X}) = \mathbb{E}_{x \sim p_X(x)} [\| G_{Y \to X} (G_{X \to Y}(x)) - x \|] \\ + \mathbb{E}_{y \sim p_Y(y)} [\| G_{X \to Y} (G_{Y \to X}(y)) - y \|] \\ \text{Equation 2 - Cycle-consistency objective.}$$

providing cycle-consistent forward and backward mappings (i.e., after one full cycle, translated samples should be as close as possible to the original samples provided as inputs), and the identity loss

$$\mathcal{L}_{id}(G_{X \to Y}, G_{Y \to X}) = \mathbb{E}_{y \sim p_Y(y)}[\|G_{X \to Y}(y) - y\|] + \mathbb{E}_{x \sim p_X(x)}[\|G_{Y \to X}(x) - x\|]$$

Equation 3 – Identity objective.

regularizing the generators $G_{X \rightarrow Y}$ and $G_{Y \rightarrow X}$, producing near identity mappings in cases when real samples of the target domain are provided as inputs.

The optimisation problem can now be represented as $G_{X \to Y}^{*}, G_{Y \to X}^{*} = \arg \min_{G_{X \to Y}, G_{Y \to X}} \max_{D_X, D_Y} \mathcal{L}(G_{X \to Y}, G_{Y \to X}, D_X, D_Y)$

Equation 4 – CycleGAN optimization problem.

where $\mathcal{L}(G_{X \to Y}, G_{Y \to X}, D_X, D_Y)$ represents a full Cycle-GAN objective function given by

$$\begin{split} \mathcal{L}(G_{X \to Y}, G_{Y \to X}, D_X, D_Y) = \\ \mathcal{L}_{adv}(G_{X \to Y}, D_Y) + \mathcal{L}_{adv}(G_{Y \to X}, D_X) + \\ \lambda_{cyc} \mathcal{L}_{cyc}(G_{X \to Y}, G_{Y \to X}) + \lambda_{id} \mathcal{L}_{id}(G_{X \to Y}, G_{Y \to X}) \\ \text{Equation 5 - CycleGAN objective function.} \end{split}$$

using λ_{cyc} and λ_{id} as the appropriate mixing coefficients.

3. BTS SSL CYCLEGAN

3.1. SEMI-SUPERVISED LEARNING

BTS SSL CycleGAN approach [1] represents a taskindependent solution for unbalanced data domains, i.e., when one of the domains is fully observable, the other one is scarce, and a certain predefined number of data samples are matched, i.e., presented in pares containing the same core information (e.g., data structure, shape, object representation) for source and target data domains. For any predefined number of labelled (paired) data samples $\{(x_i, y_i)|i=1, \dots, m\} \subset X \times Y$, a supervised training procedure is applied by introducing an additional **∥**·**∥**1 norm term given in Equation 6 into the overall objective function given in Equation 5, enforcing similarity and closeness among the same-labelled data representations. The error is calculated for both direct and inverse mappings, averaged over pairs of correlated data samples.

If *m* is the number of correlated (paired) data samples, the SSL objective is given by

$$\mathcal{L}_{SSL}(G_{X \to Y}, G_{Y \to X}) = \frac{1}{m} \sum_{i=1}^{m} [||G_{X \to Y}(x_i) - y_i||_1 + ||G_{Y \to X}(y_i) - x_i||_1]$$

Equation 6 – SSL objective.

meaning that the full BTS SLL CycleGAN objective function can now finally be defined as

$$\begin{split} \mathcal{L}(G_{X \to Y}, G_{Y \to X}, D_X, D_Y) = \\ \mathcal{L}_{adv}(G_{X \to Y}, D_Y) + \mathcal{L}_{adv}(G_{Y \to X}, D_X) \\ + \lambda_{cyc} \mathcal{L}_{cyc}(G_{X \to Y}, G_{Y \to X}) + \lambda_{id} \mathcal{L}_{id}(G_{X \to Y}, G_{Y \to X}) \\ + \lambda_{SSL} \mathcal{L}_{SSL}(G_{X \to Y}, G_{Y \to X}) \end{split}$$

Equation 7 – BTS SSL CycleGAN objective function.

for appropriate values of mixing coefficients λ_{cvc} , λ_{id} , and λ_{SSL} .

SSL strategy enables exploitation of an entire training dataset (for unlabelled samples, the standard CycleGAN objective function given in Equation 5 is applied instead of BTS SLL objective function given in Equation 7), which in turn prevents overfitting due to a limited number of paired data samples, providing better stability and increased accuracy.

3.2. BOOTSTRAPPING

Bootstrapping strategy is applied after a predefined number of training epochs, i.e., when the generator $G_{V \rightarrow V}$ is sufficiently trained and reasonably reliable, to overcome the imbalance issue between the scarce domain X and the fully observable domain Y. Randomly generated samples, produced by generator $G_{y \to x}$ previously initialised within the SLL training procedure described in Subsection 3.1 (or after the unsupervised procedure described in Section 2), are added to the training pool of discriminator of the scarce domain D_{y} (at the same time, training pool of the discriminator D_{y} remains intact). The bootstrapping is periodically repeated in conjunction with the SLL strategy during subsequent training iterations (each time more precise), replacing (instead of accumulating) previously generated samples and increasing the number of training samples in the scarce domain X. Consequently, improved discrimination capabilities of the scarce domain discriminator D_x are obtained, eventually improving the general performance of the proposed BTS SLL CycleGAN algorithm, as proven by experiments.

4. FMR CYCLEGAN

Presuming the same internal structure of direct and inverse network generators $G_{X \rightarrow Y}$ and $G_{Y \rightarrow X}$, FMR CycleGAN approach [13] introduces an additional cycle-consistent loss calculated among the same-depth input-output feature-map tensors represented as PDFs. In the case of the direct CycleGAN generator $G_{X \rightarrow Y}$, $F_{X \rightarrow Y}^{f}(x) \in \mathbb{R}^{m^{f} \times n^{f} \times d}$ and $F_{X \rightarrow Y}^{l}(x) \in \mathbb{R}^{m^{l} \times n^{l} \times d}$ represent feature-map tensors of the first and the last $G_{X \rightarrow Y}$ layer calculated for sample $x \in X$. In the case of the inverse CycleGAN generator $G_{Y \rightarrow X}$ feature-map tensors of the first and the last layer of $G_{Y \rightarrow X}$ are denoted as $F_{Y \rightarrow X}^{f}(y) \in \mathbb{R}^{m^{f} \times n^{f} \times d}$ and $F_{Y \rightarrow X}^{l}(y) \in \mathbb{R}^{m^{l} \times n^{l} \times d}$ for sample $y \in Y$.

 $F_{X \to Y}^{\{f,l\}}(x)$ and $F_{X \to Y}^{\{f,l\}}(x)$ can be reshaped into d-dimensional-column-based matrices of size $d \times (m^{[f,l]} \cdot n^{[f,l]})$ in the following way

$$F_{X \to Y mat}^{\{f,l\}}(x) = \left[F_{X \to Y 1,1,i}^{\{f,l\}}(x) | \dots | F_{X \to Y m^{\{f,l\}},n^{\{f,l\}},i}^{\{f,l\}}(x)\right]$$
(1)
$$F_{X \to Y mat}^{\{f,l\}}(x) = \left[F_{X \to Y 1,1,i}^{\{f,l\}}(x) | \dots | F_{X \to Y m^{\{f,l\}},n^{\{f,l\}},i}^{\{f,l\}}(x)\right]$$
(2)

$$F_{Y \to X \ mat}^{U, ij}(y) = \left[F_{Y \to X \ 1, 1, :}^{U, ij}(y)\right] \dots \left[F_{Y \to X \ m}^{U, ij}(f, l)_{, n}(f, l)_{, :}(y)\right]$$
(2)

Equation 8 – Feature map matrices.

Starting from the assumption that the underlying PDFs $f_{X \to Y}^{\{f,l\}}$ and $f_{Y \to X}^{\{f,l\}}$ of feature maps $F_{X \to Y}^{\{f,l\}}$ and $F_{Y \to X}^{\{f,l\}}$ can be represented as d-dimensional multivariate Gaussians, their Maximum Likelihood (ML) estimates can be obtained as

$$\Sigma_{X \to Y}^{\{f,l\}}(x) = \frac{1}{m^{\{f,l\}}n^{\{f,l\}}} \sum_{i=1}^{m^{\{f,l\}}n^{\{f,l\}}} (F_{X \to Y \ i,j,i}^{\{f,l\}}(x) - \mu_{X \to Y}^{\{f,l\}}(x)) (F_{X \to Y \ i,j,i}^{\{f,l\}}(x) - \mu_{X \to Y}^{\{f,l\}}(x))^T$$
(1)

$$\Sigma_{Y \to X}^{\{f,l\}}(y) = \frac{1}{m^{\{f,l\}}n^{\{f,l\}}} \sum_{i=1}^{m^{\{f,l\}}n^{\{f,l\}}} \sum_{j=1}^{[f,l]} (F_{Y \to X \ i,j,:}^{\{f,l\}}(y) - \mu_{Y \to X}^{\{f,l\}}(y)) (F_{Y \to X \ i,j,:}^{\{f,l\}}(y) - \mu_{Y \to X}^{\{f,l\}}(y))^T$$
(2)

Equation 9 – ML estimates of covariance matrices $\Sigma_{X \to Y}^{\{f,l\}}(x)$ and $\Sigma_{Y \to X}^{\{f,l\}}(y)$.

where

$$\mu_{X \to Y}^{\{f,l\}}(x) = \frac{1}{m^{(f,l)}n^{(f,l)}} \sum_{i=1}^{m^{(f,l)}n^{(f,l)}} \sum_{j=1}^{m^{(f,l)}} F_{X \to Y \ i,j,i}^{\{f,l\}}(x)$$
(1)

$$\mu_{Y \to X}^{\{f,l\}}(y) = \frac{1}{m^{\{f,l\}}n^{\{f,l\}}} \sum_{i=1}^{m^{\{f,l\}}n^{\{f,l\}}} \sum_{j=1}^{K^{\{f,l\}}} F_{Y \to X \ i,j,:}^{\{f,l\}}(y)$$
(2)

Equation 10 – ML estimates of mean vectors $\mu_{X \to Y}^{\{f,l\}}(x)$ and $\mu_{Y \to X}^{\{f,l\}}(y)$.

for any given $x \in X$ and $y \in Y$.

The proposed feature-map-based cycle-consistent loss term can now be defined as

$$\mathcal{L}_{FMR}(G_{X \to Y}, G_{Y \to X}) = E_{x \sim p_X(x)} \left[d_{grd} \left(f_{X \to Y}^f(x), f_{Y \to X}^l(G_{X \to Y}(x)) \right) \right] + E_{y \sim p_Y(y)} \left[d_{grd} \left(f_{Y \to X}^f(y), f_{X \to Y}^l(G_{Y \to X}(y)) \right) \right]$$

 Equation 11 – FMR objective.

where d_{grd} represents some of the ground-based distances discussed in Section 5, providing the full FMR CycleGAN objective function as

$$\begin{split} \mathcal{L}(G_{X \to Y}, G_{Y \to X}, D_X, D_Y) &= \\ \mathcal{L}_{adv}(G_{X \to Y}, D_Y) + \mathcal{L}_{adv}(G_{Y \to X}, D_X) \\ &+ \lambda_{cyc} \mathcal{L}_{cyc}(G_{X \to Y}, G_{Y \to X}) \\ &+ \lambda_{id} \mathcal{L}_{id}(G_{X \to Y}, G_{Y \to X}) \\ &+ \lambda_{FMR} \mathcal{L}_{FMR}(G_{X \to Y}, G_{Y \to X}) \end{split}$$

Equation 12 - FMR CycleGAN objective function.

for given λ_{cvc} , λ_{id} , and λ_{FMR} as mixing coefficients.

5. EXPERIMENTAL RESULTS

5.1. IMAGE-TO-IMAGE TRANSLATION

In Table 1 and Table 2, the results are presented for the Pix2Pix network architecture presented in [5], baseline CycleGAN architecture proposed in [9], BTS SLL CycleGAN architecture described in Section 3 (including the results obtained using separate SSL and BTS training mechanisms referred in Subsections 3.1 and 3.2, respectively), and the FMR CycleGAN training strategy proposed in Section 4, in terms of the standard objective Peak Signal-to-Noise Ratio (PSNR) and Structural Similarity Index (SSIM) measurements [1]. PSNR measurement is used as an energy-preserving measurement to estimate the quality of generated images versus their original counterparts. SSIM, on the other hand, evaluates image quality degradation as a perceived change in structural information. Both BTS SLL CycleGAN and FMR CycleGAN training architectures are built upon the baseline CycleGAN architecture, adding the proper loss term into the objective function, and the previously described bootstrapping mechanism in the case of the BTS SSL CycleGAN approach.

Three different image-to-image translation tasks have been conducted using various datasets (the Google Maps dataset, containing 1096 training images, the City-Scapes dataset containing 2975 training images, and the CMP Facade dataset, containing 400 training images). The final scores were calculated using 50 generated images after 200 training epochs (a fixed learning rate value of 0.0002 was used for the first 100 epochs, decaying to zero during subsequent epochs). The parameters λ_{cyc} λ_{id} λ_{SSL} and λ_{FMR} have all been fixed and set to 10. In the case of the FMR CycleGAN, various ground-based distances have been examined, namely, the robust L1-based distance (FMR_{L1}), the Kullback-Leibler divergence (FMR_{KL}), and the Log-Euclidean metric (FMR_{LE}) [13]. In the case of (semi-) supervised methods (Pix2Pix, SSL and BTS SSL), the size of the scarce domain has been manipulated {25, 50, 100}, changing the percentage of paired domain-to-domain training data. However, for the unsupervised training procedures (baseline CycleGAN, FMR_{L1}, FMR_{KL}, and FMR_{LE} CycleGANs), the whole training dataset has been employed.

Both the semi-supervised learning and the bootstrapping training strategies contribute to the increase of average PSNR and SSIM values, simultaneously improving performances of the proposed BTS SSL CycleGAN algorithm in comparison with the baseline CycleGAN algorithm, and in some cases, even the fully-supervised Pix2Pix algorithm has been outperformed.

Dataset	$S_{X}[\%]$	Pix2Pix	CycleGAN	SSL	BTS	BTS SSL	FMR _{L1}	FMR _{KL}	FMR _{LE}
	25	19.98		18.30	17.30	18.77			
CityScapes	50	20.45		18.95	17.18	19.04			
	100	19.51	17.12	20.03	17.75	20.47	17.89	18.86	17.34
	25	13.78		11.78	10.81	11.83			
CMP Facade	50	14.24		13.22	11.92	13.75			
	100	14.25	10.98	12.88	11.52	13.21	10.81	11.45	11.37
	25	30.35		30.62	30.55	31.20			
Google Maps	50	30.55		30.68	29.81	30.88			
	100	30.01	30.24	30.92	30.27	31.23	31.15	30.85	30.32

Table 1 - PSNR measures.

Fable	2	- SSIM	measures

Dataset	<i>S_x</i> [%]	Pix2Pix	CycleGAN	SSL	BTS	BTS SSL	FMR _{L1}	FMR _{KL}	FMR _{LE}
	25	0.60		0.59	0.58	0.61			
CityScapes	50	0.64		0.61	0.59	0.64			
	100	0.59	0.54	0.58	0.63	0.65	0.58	0.65	0.56
	25	0.35		0.31	0.27	0.32			
CMP Facade	50	0.40		0.37	0.28	0.40			
	100	0.42	0.27	0.33	0.35	0.41	0.31	0.29	0.28
	25	0.67		0.73	0.75	0.77			
Google Maps	50	0.68		0.75	0.76	0.79			
	100	0.69	0.73	0.75	0.77	0.81	0.76	0.74	0.73

Also, due to the additional alignment between feature maps of input-output generators layers, compared with the baseline CycleGAN algorithm, FMR CycleGAN provides better results in most cases and for all ground distances used (FMR_{L1}, FMR_{KL}, and FMR_{LE}). Visually pleasing and structurally more accurate results have been obtained using the proposed BTS SSL and FMR CycleGAN algorithms in comparison to the baseline CycleGAN and Pix2Pix (Figure 1).

5.2. SPEECH ENHANCEMENT

The BTS SSL CycleGAN algorithm described in this paper has also been applied within a speech enhancement, i.e. noisy to clean speech translation (style adaptation) task [2]. The results are given in Table 3 and Table 4, in terms of the Perceptual Evaluation of Speech Quality (PESQ, [14]) measures PEQMOS and MOSLQO, and the Virtual Speech Quality Objective Listener (ViSQOL, [15]) measures VISQOL and NSIM, respectively. The architecture presented in [16] has been employed, enabling parallel processing of the sequential data. 5000 training epochs have been conducted, using the generator(s) learning rate of 0.0002, and the discriminator(s) learning rate of 0.0001.

Spectral features have been extracted from randomly chosen signal snippets of 128 frames. The training database contains 200 clean and 200 artificially generated noisy speech samples (including both stationary and non-stationary noise components, such as background speech, traffic noise, creaking, etc.). The results are averaged over 50 test samples, by comparisons between the transformed noisy to clean speech samples and their clean speech counterparts. Presented results support our previous observations (BTS and SSL components separately, as well as in conjunction, provide more favourable results compared to the baseline Cycle-GAN algorithm for any percentage of the scarce noisy speech domain used in a supervised manner). Figure 2 shows the spectrograms of a selected noisy part of a noisy speech signal transformed using the proposed algorithms (blue-green-yellow colour range symbolises lowest to highest noise energy). While preserving the vocal component in most cases (speech around nonstationary noise components has been filtered in some cases), noise has been significantly reduced, which also corresponds to the results obtained by subjective (listening) evaluations.



Figure 1 – Google Maps image-to-image translation task (100% of the scarce domain used).

<i>S_x</i> [%]	CycleGAN		SSL		BTS		BTS SSL	
	PEQMOS	MOSLQO	PEQMOS	MOSLQO	PEQMOS	MOSLQO	PEQMOS	MOSLQO
25			0.831	1.179	0.832	1.171	0.837	1.178
50			0.864	1.184	0.842	1.186	0.857	1.191
100	0.828	1.178	0.853	1.211	0.850	1.232	0.867	1.238

Гable 3 -	PESQ	measures
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14

<i>S_x</i> [%]	CycleGAN		SSL		ВТ	BTS		BTS SSL	
	VISQOL	NSIM	VISQOL	NSIM	VISQOL	NSIM	VISQOL	NSIM	
25			1.384	0.572	1.399	0.573	1.392	0.579	
50			1.409	0.572	1.410	0.575	1.425	0.581	
100	1.369	0.569	1.436	0.576	1.391	0.575	1.452	0.585	





Figure 2 - Spectrograms of the transformed noisy speech signal (noise component).

6. CONCLUSION

In this paper, the performances of the proposed BTS SSL CycleGAN algorithm, introducing a semi-supervised learning strategy and a bootstrapping method, and the FMR CycleGAN algorithm, adding an additional feature map regularisation, have been compared among each other and also against the baseline unsupervised CycleGAN and supervised Pix2Pix approaches. The first one improves performance in the case of highly imbalanced domain-to-domain style adaptation tasks. The second one achieves more favourable results in an unsupervised training scenario, compared to the baseline unsupervised CycleGAN approach, and close to the supervised Pix2Pix approach. Improvements behind the bootstrapping logic of the BTS SSL, reducing computational complexity of geodesic and information distances calculations during the FMR training phase, improving the performance of speech enhancement around nonstationary noise components, and analysing additional use case scenarios, such as speech style (emotion) transformation, will be the subject of future study.

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COMPUTER SCIENCE AND ARTIFICIAL INTELLIGENCE SESSION

REVEALING TOLUENE BEHAVIOUR IN THE ATMOSPHERE BASED ON COUPLING OF METAHEURISTICS, XGBOOST, AND SHAP

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Abstract:

This study used an improved version of the reptilian search algorithm to investigate atmospheric patterns of toluene and its interactions with other polluting species under different environmental conditions. Toluene is a harmful aromatic hydrocarbon known for its role in the formation of secondary atmospheric pollutants. In this study, a two-year database of hourly pollutant concentrations, such as toluene, was analysed. The results were validated against other models using metaheuristic algorithms, and Shapley's additive explanations method was used to interpret them. The findings indicated a distinct correlation between toluene and m,p-xylene, and the study described the environmental conditions that influence their interactions. Overall, this research highlights the significance of using advanced analytical techniques to better understand the relationships between pollutants and their behaviour in different environmental conditions.

Keywords:

Machine Learning, Extreme Gradient Boosting, Metaheuristics, Explainable Artificial Intelligence, Volatile Organic Compounds.

INTRODUCTION

Air pollution involves intricate processes such as the dispersion, accumulation, or deposition of pollutants, which are affected by several factors, including pollutant interactions, unevenly distributed emission sources, measurement site characteristics, and meteorological conditions. To comprehend the behaviour of pollutants and their harmful effects on human health and the environment, data-driven research is essential. The complexity of air pollution-related processes necessitates an in-depth understanding of the underlying mechanisms, which can only be achieved through data-driven research.

Toluene is a mono-substituted aromatic hydrocarbon and its primary sources are traffic exhaust, cigarette smoke, and anthropogenic activities related to fuel, paint, adhesive, cleaner, polish, rubber, and lacquer production and use. Previous studies have shown that toluene concentrations range from 5 to 150 μ g m⁻³ in urban locations, with extreme values near volatile pollutant sources [1]. Toluene is not prone to bioaccumulation and is rapidly absorbed, distributed throughout the body, and concentrated in vascularized organs, particularly the brain, due to its affinity for lipid-rich tissues [2].

Toluene concentration is regularly monitored due to its toxicity on the nervous system and permanent brain damage observed in adhesive abusers [3]. Toluene is not labelled as carcinogenic, but in urban locations, anthropogenic benzene and toluene emission sources play a substantial role in ozone photochemistry and SOA-forming contribution, especially in low-NO_x regimes [4].

Our previous studies have tackled issues in analysing air pollution in complex urban environments, including the need for proper contextualization of data [5], [6], [7], [8], [9], and the use of statistical methods and artificial intelligence algorithms [10], [11] and [12]. In terms of data modelling, metaheuristic algorithms are commonly used to address nondeterministic polynomial (NP)-hard problems, particularly in machine learning hyperparameter optimization, due to their stochastic nature. In this study, we apply an enhanced variant of the reptile search algorithm (RSA) being hybridized with the firefly algorithm (FA) for resolving the shortcomings of the elementary RSA. The enhanced version of RSA metaheuristics is applied as an integral component of the machine learning framework to optimize the set of the XGBoost hyperparameters for toluene atmospheric fate research. The best-produced model is interpreted by applying Shapley Additive exPlanations (SHAP).

2. METHODOLOGY

2.1. DATA

For the analysis, we used the concentrations of inorganic gaseous pollutants (NO, NO₂, NO₂, O₃), particulate matter (PM₁, PM₂₅, and PM₁₀), and benzene, toluene, mp-xylene, and total non-methane hydrocarbons (TNMHC) obtained from the station of regulatory air quality monitoring Vatrogasni Dom in Pančevo, Serbia [13]. Additionally, meteorological parameters attained from the Global Data Assimilation System - GDAS1 [14], were used to complement the two-year (2019-2020) database of air pollutants. Hourly concentrations of organic pollutants (benzene, toluene, and m,p-xylene) and inorganic gaseous pollutants (NO, NO₂, NO₃, and O₃) were measured using referent sampling devices that adhere to European standards EN 14662-3, EN 14211, and EN 14625. The GRIMM EDM 180 measuring method was used to determine hourly concentrations of particulate matter, following the standards EN 12341 and EN 14907, while a gas chromatograph Syntech Spectras GC955 was employed for the concentrations

of TNMHC. This device separates methane from other hydrocarbons and measures the concentration of both methane and other total non-methane hydrocarbons in the air.

2.2. STUDY AREA

Pančevo, with over 100,000 inhabitants, is situated on the left bank of the Danube, 20 km east and northeast of Belgrade, the largest Serbian metropolitan area. The sampling site (44°51′31″ N, 20°38′56″ E) is an urban background station located about 500 m south of the city centre at the regional fire station. The surrounding areas include residential areas to the east and northeast, a scrap metal sorting and storage centre, and a flour production factory. The E70, a European corridor with public transport and intensive vehicle flow, passes about 200 m in the S-SW direction from the sampling site. The confluence of the Tamiš and Danube rivers is located approximately 500 m in the SW direction. The South industrial zone of Pančevo, which includes three main factories: HTP Azotara, HTP Petrohemija, and Pančevo Oil Refinery, is situated two kilometres SE of the sampling station. The station is positioned in the dominant southeast direction of wind between the industrial zone and the city centre, according to the Air quality control program for the City of Pančevo and the Air Quality Plan for the City of Pančevo.

2.3. EXTREME GRADIENT BOOSTING - XGBOOST

XGBoost is a machine learning algorithm based on an ensemble of decision trees, where each tree is trained to correct the errors of the previous tree in the sequence. One of the key advantages of XGBoost is its ability to handle large datasets with high-dimensional features. It employs a regularization technique to prevent overfitting and can handle missing values in the data. The algorithm is highly customizable, allowing for the tuning of parameters such as learning rate, maximum depth, and number of trees to optimize performance. The details about XGBoost are provided elsewhere [15].

2.4. METAHEURISTICS

NP-hard challenges are a frequent occurrence that often requires the use of stochastic algorithms like metaheuristics because deterministic methods are impractical. Metaheuristic algorithms can be classified into various families based on the natural phenomena they imitate to guide the search process, such as evolution or insect behaviour [15]. The most significant families are nature-inspired methods (genetic algorithms and swarm intelligence), physical phenomenon-based methods (such as storms, gravity, and electromagnetism), algorithms that imitate human behaviour, and approaches based on mathematical laws.

Swarm intelligence is based on the coordinated and sophisticated behavioural patterns manifested by large groups of relatively modest units, such as insects or birds in swarms, while they hunt, feed, mate, or migrate [16]. These algorithms have proven highly efficient in solving various real-world NP-hard challenges. Well-known examples include particle swarm optimization (PSO) [17], ant colony optimization (ACO) [18], firefly algorithm (FA) [19] and bat algorithm (BA) [19]. More recently, highly efficient algorithms based on mathematical functions and their properties have emerged, such as the sine-cosine algorithm (SCA) [20] and arithmetic optimization algorithm (AOA) [21].

In this paper, we used a modified reptile search algorithm (RSA) inspired by crocodiles' hunting style [22] the RSA lacked sufficient exploitation power despite excellent exploration capability. We found the diversification-intensification trade-off balance biased towards exploration. We proposed integrating RSA with the FA to achieve a suitable balance between exploration and exploitation. The low-level hybrid approach combines both metaheuristics, with RSA at the start and FA during the search process to enhance the RSA's performance. The approach addressed RSA's weaknesses and improved its effectiveness in identifying optimal search regions.

2.5. SHAPLEY ADDITIVE EXPLANATIONS

To gain insight into the decision-making process of a best-performing model, we employed the explainable artificial intelligence SHAP (SHapley Additive exPlanations) method [23]. SHAP allows for a meaningful and straightforward interpretation of the decisions derived from the model, without sacrificing accuracy or interpretability. It is based on a game-theory approach that calculates Shapley values as a feature importance measure, which provides an understanding of the impact of each feature on individual predictions.

The Shapley values represent fairly distributed payouts among the cooperating players (features) depending on their contribution to the joint payout (prediction). SHAP assigns an important measure to each feature as a measure of its contribution to a particular prediction and compares its impact to the model's prediction if that feature took some baseline value (mean). This provides valuable insights into the model's behaviour by overcoming the main drawback of inconsistency, minimizing the possibility of underestimating the importance of a feature with a specific attribution value, and capturing feature interaction effects. However, the main challenges of the method include the computation of Shapley values and the choice of background data, which can lead to uncertain or unintuitive feature attributions.

3. RESULTS

As shown by mean absolute and relative SHAP values (Table1), the concentrations of benzene, followed by m,p-xylene levels, appeared to be the major factors that shape the toluene dynamic in the air. Additionally, the toluene's environmental fate is affected by the concentrations of THNMC, PM1, and NOX, as well as meteorological parameters, including volumetric soil moisture content (SOLM) and the direction and intensity of momentum flux (MOFD and MOFI). In the present study, to demonstrate the potential of the applied methodology, we will focus on m,p-xylene as the main predictor.

	Benzene	mpXylene	TNMHC	PM_1	NO _x	SOLM	MOFD	MOFI	NO ₂	NO	PM ₁₀	T02M
Absolute SHAP	1.28	0.85	0.25	0.11	0.09	0.07	0.05	0.04	0.03	0.03	0.03	0.03
Relative SHAP [%]	36.09	27.27	8.31	3.06	3.05	2.43	2.01	1.49	1.12	1.23	0.94	0.91

The results suggest that m,p-xylene concentrations of 0.85 µg m⁻³ on average govern the toluene dynamics in the air as shown by absolute SHAP values. The most positive impact of m,p-xylene on the toluene dynamics is accompanied by the increase of m,p-xylene levels (up to 5 μ g m⁻³) as well as by the lowest concentrations of the inorganic gases, volatile non-aromatics and particles. The interrelationships between benzene homologues, m,p-xylene and toluene, could be explained by their coexistence in ambient air. Although toluene contains one methyl group which can be placed at any position on the benzene ring and m,p-xylene has two methyl groups attached to the benzene ring, they share common emission sources. The most dominant sources originated from anthropogenic activity including the petrochemical industry, chemical production of organic solvents and evaporative emission from storage facilities, but also to a lesser extent combustion of fossil fuels for heating and traffic purposes. The low to moderate levels of other pollutants in environmental conditions are associated with a negative impact of m,p-xylene, resulting in a decrease in toluene levels of up to 2.7 μ g m⁻³, while the highest concentrations of other pollutants are mostly associated with a moderate positive and negative impact on toluene dynamic (from -1.6 to 2 µg m⁻³). Positive impact suggests the occasional influence of common sources of toluene and NOX and THNMC whereas negative interrelations imply different sources and the possible different behaviour of the pollutants in the air.

When PM is present in the air, the photochemical oxidation of aromatics such as toluene contributes to SOA formation (95%) compared to volatile organics and alkenes [24]. Similarly, Zhan et al. [25] reported that aromatics dominantly lead to the production of ground-level O_3 .

The increase in m,p-xylene levels is linearly correlated with PM_1 , $PM_{2.5}$, TNMHC, and NO_2 concentrations, but not with benzene and NO (Figure 1-3). High levels of NO were observed when lower levels of m,p-xylene were recorded (Figure 2), whereas higher concentrations of m,p-xylene corresponded to lower values of benzene (Figure 3) indicating the impact of different emission sources surrounding the measuring site. Additionally, an area of moderate influence of m,p-xylene on toluene is observed, when m,p-xylene concentrations are in the interval from 10 to 25 μ g m⁻³, and NO records high values - above 100 μ g m⁻³ (Figure 2).

The analysis shows that low air and soil temperatures, high relative humidity, low PBLH, and stable atmospheric conditions as indicated by the other meteorological parameters, accompany the highest levels of all analysed polluted species. The conditions could be associated with the cold part of the year (winter and autumn months) when unfavourable meteorological conditions together with intensified fossil fuel burning for heating purposes contribute to high concentrations of pollutants. In addition, toluene and m,p-xylene removal through photochemically induced reactions are suppressed during the cold periods.



Figure 1 – Absolute m, p-xylene impact on toluene in the context of PM_{25} .



Figure 2 – Absolute m, p-xylene impact on toluene in the context of NO.

20



Figure 3 - Absolute m, p-xylene impact on toluene in the context of benzene.

4. CONCLUSION

Toluene is widespread in the atmosphere because it is used in many commercial products and when it is present at high concentrations, this pollutant poses serious adverse effects on human health. The behaviour of toluene in air is complex and its lifetime and abundance highly depend on environmental factors including meteorological conditions, the presence and intensity of emission sources and interactions with the other (co)polluting compounds. The present study using metaheuristics, XGBoost, and SHapley Additive exPlanations methods showed that concentrations of m,pxylene mainly impact the dynamic of toluene in air. The positive interrelations between toluene and m,p-xylene could be linked with common emission sources and favourable values of temperature, humidity and PBLH.

5. ACKNOWLEDGEMENTS

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SINTEZA 2023

COMPUTER SCIENCE AND ARTIFICIAL INTELLIGENCE SESSION

IMITATION DRAWING: CAN WE SPOT THE DIFFERENCE BETWEEN AI AND HUMAN GENERATED DRAWING?

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Abstract:

Questions that have gained importance with the rise of artificial intelligence (AI): can we discern between image output created by humans versus that generated by AI? In this study, a diverse group of students and educators were presented with a range of tasks to determine whether image outputs were produced by humans or artificial intelligence (AI). The results of the study indicate that both teachers and students were able to differentiate between human and AI-generated outputs with accuracy from 32% to 79% on group images and from 54% to 82% on single images, although performance varied depending on the complexity of the task and participants' level of familiarity with AI. As the prevalence of AI-generated content continues to grow, it is crucial to comprehend how individuals can identify its use. This study highlights the significance of educating people on AI and the subtleties of image output in the era of AI. Overall, it is critical to continue exploring and understanding the intricate relationship between humans and AI as technology continues to advance.

Keywords:

Artificial Intelligence, DALL-E, AI generated images, Education and AI.

INTRODUCTION

As artificial intelligence (AI) rapidly advances, it becomes increasingly important to examine how people distinguish between drawn outputs created by humans versus those generated by AI. This study aimed to explore this question by conducting various tasks for a diverse group of students and teachers to identify whether an image output was produced by a human or an AI. As the use of AI-generated content becomes more prevalent in different fields, it is crucial to understand how people can identify between AI and human generated content. This study highlights the significance of educating individuals on the intricacies of image output in the era of AI, and the need to continue investigating the relationship between humans and technology.

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The release of OpenAI's ChatGPT-3 has sparked concern among people who fear its potential impact on multiple fields. While the technology can be used for cheating and creating plagiarised work, it also has the potential to enhance the learning experience, and produce novel ideas. This commentary offers opportunities for educators and research potential for scholars [1]. In this study we will compare the output of the DALL-E language driven image creation and human generated images.

The results of the study suggest that both teachers and students were able to distinguish between human and AI-generated content with a relatively high level of accuracy, from 32% to 79% on group images and from 54% to 82% on single images.

However, there were variations in performance depending on the task's nature and the participants' level of experience with AI technology. The relationship between humans and AI continues to evolve rapidly, and it is essential to continue exploring and understanding this complex interaction. This study provides valuable insights into the ability of teachers and students to differentiate between human and AI-generated outputs, and it calls for further research in this area.

2. RELATED WORK

As AI technology continues to advance, it is becoming increasingly difficult to distinguish between content generated by humans and content generated by machines. From text to image (Stable Diffusion, Midjourney and DALL-E 2)[2], audio, video, and chatbots (ChatGPT) [3], AI-generated content is becoming more sophisticated, and in some areas, even surpassing human-generated content. This raises questions about the role of AI in various fields and the potential impact on human creativity and productivity. In this context, it is important to explore the capabilities and limitations of AI-generated content and understand how it can be effectively used alongside human-generated content.

As more organizations implement artificial intelligence-based service agents to provide automated customer service, it is important to understand how users perceive this new form of communication [4]. AI-based service agents use natural language interaction to communicate with users, but instead of a live person, a chatbot controls the conversation using artificial intelligence. The authors of this study use qualitative and quantitative methods to investigate users' perceptions of authenticity and its impact on their attitudes and behavior towards AI-based service agents. They found that users judge the authenticity of AI-based service agents based on two categories of cues: agent-related and communicationrelated. The authors plan to use additional experimental studies to further explore the antecedents and consequences of authenticity perceptions in AI-based service encounters. The researchers are conducting a study on agent-related and communication-related cues to distinguish between human and AI service agents. The study has analyzed 41 interviews and 10 think-aloud protocols and identified two cue categories as central to the study.

The use of Artificial Intelligence (AI) in education, particularly in the form of chatbots, has raised concerns about its impact on academic integrity [5]. Study [5] aimed to assess the originality of academic essays generated by one of the most popular AI chatbots, ChatGPT, using two plagiarism detection tools. Results revealed that ChatGPT has the potential to produce high-quality content with high originality that can bypass traditional plagiarism checks. The study highlights the need for institutions to take appropriate measures to address potential plagiarism issues and engage in ongoing discussions about the impact of AI technology on education. The paper further discusses the implications of the study findings. The use of chatbots, such as OpenAI ChatGPT and Google Bard AI, in education has potential benefits but also raises concerns about academic integrity. A study found that 40 out of 50 essays generated by ChatGPT had a high level of originality, raising questions about the reliability of plagiarism check software. To address this problem, the study suggests that teachers inform students of the limitations of ChatGPT and promote critical thinking, students use ChatGPT as a means to improve their learning but not as a substitute for original thinking, and institutions create clear policies and guidelines for the responsible use of AI tools in education. The study also highlights the need for training and resources on academic integrity and the responsible use of AI tools in education.

In recent times, researchers have expressed concerns about AI generated images and human generated output. Paper [6] has been written to provide an examination of deep convolutional generative adversarial networks (GANs) and to explore the potential use of AI generated images. The research showed that images generated by AI are getting better and better, some of them can be misleading and cannot be differentiated between human and AI output. Paper [7] represents the superiority of AI generated images by Stable Diffusion, Midjourney, and DALL-E 2, but is still concerned about some features photo realistic like face generation. Study also showed that some models like Stable Diffusion can produce better realistic faces than other models.

The main problem in the future of AI generated content is that we are making the difference between AI and human generated content smaller and smaller. This already affects the art competition where participants are submitting the AI generated art as in human competition, from photographs to digital art.

3. THE PROPOSED METHOD

In this paper, we have a method to assess the effectiveness of artificial intelligence (AI) in generating artwork using DALL-E software. The proposed approach involves administering a questionnaire to both students and teachers in two stages.

First stage will take participants which will be asked to differentiate between artwork generated by AI and that produced by students. This will be accomplished by presenting a set of four pictures, one of which will be generated by AI and the other three by students. Participants will then be asked to identify the AI-generated artwork. This is represented in Figure 1.

In the second stage, the focus will shift to a single image. Participants will be presented with a series of images and asked to determine whether each one was generated by AI or by a human student shown in Figure 2. Overall, this approach provides a rigorous and objective means of evaluating the effectiveness of AI in generating artwork. It has the potential to shed new light on the capabilities of AI and inform future developments in this rapidly advancing field.

4. EXPERIMENTS

In this experiment we will use 64 different images in the first questioner where we have 15 images generated by AI and 45 images drawn by humans. In the second questionnaire we used 26 images where 13 images are generated by AI and 13 images are produced by humans. In Figure 1. we presented some the images used by both questionnaires and their authors generated by DALL-E and humans. The database of the entire set can be found on the github page: https://github.com/VukojicicMilic/ Imitation-drawing.

The result form the first questionnaire on the question "Which of these images was generated by AI?" are shown in Table 1, right answers are bolded in the table.



Figure 1 - Sample of images created by DALL-E and human generated images.

		Answer (%):		
Image	(a)	(b)	(c)	(d)
Images-1	4,081632653	32,65306122	14,28571429	48,97959184
Images-2	14,28571429	10,20408163	55,10204082	20,40816327
Images-3	14,28571429	73,46938776	6,12244898	6,12244898
Images-4	44,89795918	10,20408163	24,48979592	20,40816327
Images-5	34,69387755	6,12244898	53,06122449	6,12244898
Images-6	44,89795918	14,28571429	30,6122449	10,20408163
Images-7	59,18367347	2,040816327	28,57142857	10,20408163
Images-8	24,48979592	12,24489796	32,65306122	30,6122449
Images-9	32,65306122	42,85714286	18,36734694	6,12244898
Images-10	10,20408163	22,44897959	28,57142857	38,7755102
Images-11	14,28571429	61,2244898	14,28571429	10,20408163
Images-12	6,12244898	8,163265306	67,34693878	18,36734694
Images-13	6,12244898	14,28571429	14,28571429	65,30612245
Images-14	6,12244898	14,28571429	57,14285714	22,44897959
Images-15	4,081632653	10,20408163	79,59183673	6,12244898

Table 1 -	Statistics	of answers	for each	question	in the first	questionnaire	related to images.
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Source: https://github.com/VukojicicMilic/Imitation-drawing/tree/main/Group%20Images

Statistics were taken from 50 different respondents who are of different ages and of different education levels with different experience with AI. The second questionnaire showed that almost 50% of respondents can distinguish between AI and human generated artwork. The question was "Do you think this image is generated by AI or human?", the results are shown in Table 2, right answers are bolded in the table.

Table 2 - Statistics of answers for each question in the second questionnaire related to images.

	Answer (%):			Answer (%):	
Image	AI	Human	Image	AI	Human
Image1	32,60869565	67,39130435	Image14	58,69565217	41,30434783
Image2	73,91304348	26,08695652	Image15	71,73913043	28,26086957
Image3	21,73913043	78,26086957	Image16	23,91304348	76,08695652
Image4	73,91304348	26,08695652	Image17	69,56521739	30,43478261
Image5	32,60869565	67,39130435	Image18	78,26086957	21,73913043
Image6	43,47826087	56,52173913	Image19	17,39130435	82,60869565
Image7	63,04347826	36,95652174	Image20	19,56521739	80,43478261
Image8	63,04347826	36,95652174	Image21	69,56521739	30,43478261
Image9	32,60869565	67,39130435	Image22	65,2173913	34,7826087
Image10	67,39130435	32,60869565	Image23	65,2173913	34,7826087
Image11	65,2173913	34,7826087	Image24	17,39130435	82,60869565
Image12	43,47826087	56,52173913	Image25	34,7826087	65,2173913
Image13	45,65217391	54,34782609	Image26	36,95652174	63,04347826

Source: https://github.com/VukojicicMilic/Imitation-drawing/blob/main/Questionnaires/Find%20an%20AI%20 generated%20drawing%20(2).pdf Research has shown that individuals with greater skill and experience in both drawing and using text to image AI tools, such as DALL-E, tend to achieve better results on tests. This suggests that a combination of traditional artistic abilities and technological proficiency can lead to improved performance in tasks that require both. However, it is important to note that other factors, such as creativity and critical thinking, may also play a role in overall success. Therefore, developing a wellrounded skill set that includes both artistic and technological competencies may be beneficial for students and educators alike.

5. CONCLUSION

In this research study, the focus was on a crucial question in the era of artificial intelligence: can humans distinguish between image output created by humans and that generated by AI? A sample of students and teachers with diverse educational backgrounds was used, and they were presented with different tasks to identify whether the written and drawn outputs were produced by humans or AI. The study's results indicated that both teachers and students could, with great precision, distinguish between human and AI-generated content. However, the performance varied depending on the task and the participants' familiarity with AI.

As the use of AI-generated content continues to grow, it is vital to comprehend how people can identify its use. This study emphasises the importance of educating people on AI and the subtleties of written and drawn output in the age of AI. It is critical to continue exploring and understanding the relationship between humans and AI as technology advances.

One possible next topic for research could be the impact of AI on employment and the workforce [8]. This is a topic of growing importance as AI and automation technologies are increasingly being adopted in various industries, which has the potential to displace human workers from their jobs. Some key questions that could be explored in this area include:

- How will the job market evolve in response to AI adoption?
- What skills and training will be necessary for workers to remain employable in the age of AI?
- How to adapt the current educational system for AI's future?
- What policies and programs can be put in place to support workers in transition?

There are many different angles and approaches that can be taken in this area of research, making it a rich and interesting field to explore.

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SINTEZA 2023 INTERNATIONAL SCIENTIFIC CONFERENCE ON INFORMATION TECHNOLOGY, COMPUTER SCIENCE, AND DATA SCIENCE

COMPUTER SCIENCE AND ARTIFICIAL INTELLIGENCE SESSION

GENERATIVE ARTIFICIAL INTELLIGENCE FOR RETINAL DEGENERATION: A REVIEW

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Abstract:

Every stratum of professionals has been impacted by the rapid improvements in technology. Artificial intelligence (AI) has had a genuinely unmatched impact on the fields of transportation, agriculture, meteorology, and health. We can now anticipate the future more accurately and confidently using AI using historical datasets. Although there are many applications for AI, this research focuses only on generative AI for the diagnosis of retinal disorders. The generator and the discriminator are the two primary models used in generative AI. While the discriminator tries to distinguish between accurate and false, the generator is employed to generate noisy random input. Together, these two models operate. For the treatment of retinal illnesses such as diabetic retinopathy, also known as DR, age-related macular degeneration, or AMD, and Retinal Fundus, commonly known as RF, ophthalmologists have used Generative AI. Based on the input datasets, generative AI may categorize them into specific groups by recognizing patterns in data. The subject of generative AI is relatively young, and numerous datasets are needed for it to gain experience as a stakeholder. Nevertheless, with every opportunity comes a challenge. The interpretation of technology-generated data that are outdated, technical difficulties, patient and physician approval of the algorithm, and its legal implications are further possible roadblocks for technology in ophthalmology. In a nutshell, yes there are challenges to the use of AI technology in diagnosing diseases related to ophthalmology, but these challenges can be solved. Hence, the future of Generative AI shows a bright picture in clinical development.

Keywords:

Artificial Intelligence, AMD, DR, Generative AI, Discriminator, Retinal Fundus.

INTRODUCTION

There are 285 million visually impaired persons worldwide, of whom 39 million are blind, according to the World Health Organization (WHO) [1]. The main reason for such a staggering of visually impaired people is retinal diseases. The most notable diseases that cause visual impairment are Glaucoma, Cataracts, Age-related macular degeneration (AMD), Diabetic retinopathy (DR), and Ocular surface neoplasia [2]. There are different reasons for each of these diseases to occur. Glaucoma is caused by an abnormality in the drainage mechanism of the eye, which results in a build-up of fluid around the optic nerve, ultimately resulting in the loss of sightedness.

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e-mail: fakhra.csit@must.edu.pk Cataract and Age-related macular degeneration are caused by aging, diabetes, smoking, previous eye injury, and high blood pressure [3]. And the last one Ocular surface neoplasia occurs due to exposure to solar ultraviolet radiation (UV), Human immunodeficiency virus (HIV), and human papillomavirus (HPV). According to scientific studies, all these visual impairments and their causes are preventable in their early ages, to be more specific they can be cured with almost 80pc success rate [1]. However, with time these disorders become irreversible, and the patient will have to suffer from long-lasting blindness.

Out of all the eye diseases mentioned above, two of them are more common; age-related macular degeneration (AMD) and diabetic retinopathy (DR) [4]. According to estimates around 170 million people around the globe are affected by the former retinal disease, while onethird of all the people who suffer from diabetes, which is around 285 million, have shown the symptoms of diabetic retinopathy. In recent years these numbers have been increasing and there are projections for the future which do not look good. According to projections, over 288 million individuals will have AMD by 2040, and the number of DR patients will triple by 2050 [5]. This startling figure paints a bleak picture of the future and necessitates action to combat these retinal illnesses.

Ophthalmologists all over the world have developed drugs to treat various disorders over the years. Intravitreal vascular endothelial growth factor (VEGF) suppression, which was established in 2006, is one of them [6]. This was a major success, and it made a significant difference in preventing and lowering the incidence of legal blindness. This anti-VEGF drug was used to treat patients with diabetic macular edema (DME). However, the success of anti-VEGF medication quickly faded, owing to delays in diagnosing illness initiation and progression, as well as the unpredictability of recurrence, all of which derail long-term care [7]. Even blocking complement factors, thought to be one of the main causes of geographic atrophy (GA), has not been able to stop the disease's progression or the loss of vision, leaving the topic of effective therapy targets and pertinent biomarkers open [8]. Additionally, a number of studies have shown negative effects in recent years as a result of the prolonged use of anti-VEGF drugs and the rise in the number of injections conducted internationally, including increased intraocular pressure and unsightly silicone oil vesicles in the vitreous cavity [9]. As a result, retinologists have been unable to devise a viable remedy that may prevent long-term vision deterioration in large patient populations, and healthcare providers have experienced a significant economic drain as a result of unsuccessful research trials [10].

Artificial intelligence is better known as the fourth industrial revolution [11]. It consists of various fields: supervised and unsupervised learning. The former is defined as a machine learning (ML) type where a model is trained on labeled data, meaning that the desired output or target variable is provided along with the input data. The goal is for the model to learn to predict new, unseen data based on the patterns it learned from the training data. While the latter is also a type of machine learning where a model is trained on unlabelled data, meaning that the desired output or target variable is not provided. Here the goal is for the model to find patterns or structure in the data on its own. Generative AI is the combination of unsupervised and semi-supervised learning. AI, since its introduction in 1956 by John McCarthy, has changed the lifestyle of human beings. It is used everywhere in judging customer preferences, from the transpire ort industry, in the form of driverless cars, to the hotel industry [10]. AI is used in the agricultural sector to predict future yields, forecast the weather, and monitor crop health and the irrigation system.

Thus, it is no exaggeration to say that artificial intelligence (AI) is used everywhere in our daily life, this review summarizes the use of generative AI in the field of ophthalmology, the potential of generative AI models, possible challenges for it, and the way forward.

2. DIFFERENT SOLUTIONS TO RETINAL DISEASES

The non-invasive, high-resolution optical imaging technique known as optical coherence tomography (OCT) is based on the interference of a signal from the item being analyzed and a nearby reference signal [12]. OCT can create a cross-section image of the item or a two-dimensional image in space in real-time, lateral coordinate, or axial coordinate. Because of the combination of the eye's aberration and low numerical aperture, confocal microscopy is limited when used to scan the retina of the human eye. The numerical aperture of the microscope objective governs both the lateral and axial resolutions in confocal microscopy. Spectral-domain (SD)-OCT is widely available and employed in the treatment of major retinal diseases such as choroidal neovascularization (CNV) and diabetic macular edema (DME) [13]. The traditional three-dimensional OCT image is based on approximately 20,000-52,000 A-scans per second with a resolution of 5 to 7 micrometres [14]. The identification of blood flow is possible thanks to OCT technology's high-speed and efficient algorithms (a collection of rules and methods to solve a problem). Given the busy work schedule of an ophthalmologist, it would be nearly impossible for an ophthalmologist to scroll through a series of about 250 B-scans for every dozen retina patients seen daily [15].

With such a large amount of data available, each patient acts as a "big data" challenge because it increases the complexity of a disease. Thus, the new era of diagnostics requires intelligent tools to maintain a large bulge of data safely and efficiently. To effectively manage such a large sum of data the role of new technology, i.e., artificial intelligence, increases. TI has pronounced its effectiveness and strength in every walk of life ranging from agriculture, businesses, weather forecasting, and population projection. In the field of medicine AI is being used in dermatology (the study of hair, skin, and nails), radiology a (branch of medicine that uses imaging technology to diagnose disease), and pathology. Consequently, through AI physicians could learn and detect different diseases after scanning a large volume of image data. It is not an exaggeration that AI is the future, and it would foster the knowledge of ophthalmologists.

3. THE EMERGENCE OF GENERATIVE ARTIFICIAL INTELLIGENCE

As mentioned earlier AI is the branch of computer science that deals with the invention of intelligent machines. The field of artificial intelligence is very diverse, and it encompasses within itself different branches, generative AI is one of them. A subfield of computer science called generative artificial intelligence (GAI) uses unsupervised and semi-supervised techniques to let computers build new content out of previously existing stuff including text, music, video, graphics, and code [16]. It all comes down to producing wholly original artifacts that seem legitimate. In other words, generative AI is a subfield of machine learning that focuses on designing algorithms that can generate new data. Robotics, computer vision, and the arts and music are all using generative models. The term "generative" in this context refers to the process by which these models learn to generate new data rather than simply recognize it. A generative model, for example, may learn how to make images that resemble faces given a collection of parameters (such as the number of eyes or hair color).

Although generative AI is not a new thing, over the years it has evolved, and different approaches are used in this field to solve day-to-day problems. The models of deep learning (DL) and generative adversarial network (GAN) approaches were being used, but the latest approach of the generative approach of AI i.e., transformers has revolutionized everything.



Figure 1 - The working principle of generative AI.

The concept of Deep learning (DL) is a subset of machine learning. The machine itself identifies by looking at the pattern, that is concerned with algorithms inspired by the structure and function of the brain called artificial neural networks. These neural networks are built to recognize patterns and make judgments, and they are especially well suited for tasks like picture and audio recognition, natural language processing, and decision-making. Large sets of labelled data are used to train DL models, and they automatically learn and improve based on the data they are given. They can learn numerous layers of abstraction and hence complete extremely difficult jobs [17]. It's important to note that DL is a branch of machine learning, and it uses neural networks as the main building block, neural networks are modelled after the human brain, and it is a subset of artificial intelligence (AI) that deals with training multi-layered neural networks, which are called deep neural network [18]. The practical application of the DL is in areas like the banking sector for the detection of fraud, weather forecasting, etc. [19].

Generative Adversarial Network (GAN) is a type of deep learning model that's used to produce or generate a completely new dataset based on given training. There are two main components of the GAN, a generator network, and a discriminator network [20]. The former is used to provide new data samples that are analogous to the training data. It takes random inputs and caps able to generate an output, which is a new data sample. The discriminator is given the task to differentiate between the generated data sample and the real data sets from the training dataset. It takes in a data sample and produces a probability score indicating how likely it is that the sample is real. Interestingly, these two components of GAN work against each other, the generator strives to come up with a difficult dataset, to make the discriminator fool. While the discriminator tries to be better at identifying the fake samples [20]. The concept of GAN is used in video editing, text-to-speech conversion, noise removal from data, 3D object generation, and drug discovery [21].

The latest approach of the GAN, transformers, has changed everything. The development of generative pertained transformers (GPT) is a type of large language model that effectively uses deep learning to generate text like human beings. Back in November 2022, the OpenAI company launched an online chatbot, "ChatGPT" that uses GPT-3 [22]. This chatbot is fully capable of generating text and answering questions. Academicians around the world have now found it difficult to understand the difference between human writing and computergenerated essays [23]. In conclusion, the field of generative AI is changing the world due to its rapid solution to the world's complex problems. Their application is everywhere from engineering to medicine, banking to meteorology, and to education. According to reports, the scientist believes that by 2030, this field would generate an economy of 15.7 trillion USD [24]. So, it is pertinent to use these novel technologies for the treatment of different retinal disorders.

4. USING GENERATIVE AI TO COMBAT RETINAL DISEASE

A. TREATMENT OF DIABETIC RETINOPATHY USING DL

By 2040, 600 million individuals worldwide would have diabetes, with one-third developing diabetic retinopathy (DR). According to one study conducted on 22,896 persons with diabetes from various nations such as Australia, India, and other European countries between 1980 and 2008, according to this study [25]. The results of this study showed that out of all the patients with diabetes, 35% were suffering from retinal disease, particularly from the DR. However, through timely treatment lifetime, blindness can be prevented. The classical method of treating DR has many issues like implementation, availability of human resources, and long-term economic sustainability [26].

The development of deep learning (DL) has improved diagnostic performance in detecting diabetic retinopathy. In a study by Abramoff, it was found that the DL mechanism of detecting DR could identify referable DR on the Messidor-2 dataset with an area under the receiver operating characteristic curve (AUC) of 0.980, a sensitivity of 96.8%, and a specificity of roughly 87.0% [27]. Another study by Gulshan from Google AI Healthcare found that the DL system performed well in terms of diagnostic performance when dealing with DR. The AUC, sensitivity, and specificity of the DL system, which was constructed using the DL architecture VGG-19, were found to be 0.936, 90.5%, and 91.6% in detecting referable DR, respectively, and the same architecture yielded data of 0.95, 100%, and 91.1% in detecting vision-threatening DR [28].



Figure 2 - Shows the working of deep learning in ophthalmology [33].

B. MAGE-RELATED MACULAR DEGENERATION AND DL

Age-related Macular Degeneration (AMD) is majorly caused by age factors. According to the American Academy of Ophthalmology's study, around 288 million people will suffer from some or other form of AMD by 2040. Out of this population, approximately 10% would have intermediate AMD or worse [29]. With such a large population on the verge of a catastrophe, dire actions are needed to resolve this issue.

To diagnose AMD, the concept of deep learning is used. According to a study by Ting et al, the DL method detecting AMD has proved successful. The DL system was trained and tested using 108,558 retinal images taken from 38,139 patients [30]. The accuracy report calculated by Burlina et al was between 88.4% to 91.6% and with the area under the receiver operating characteristic curve (AUC) between 0.94 to 0.96 [31]. However, these pictures were taken in analog format and then these pictures were converted into digital form, whether this transition from analog to digital format can affect the accuracy is still unknown [32].

C. GANS FOR RETINAL FUNDUS IMAGE SYNTHESIS

The fundus refers to the eye's inside and posterior surfaces. This structure is made up of the retina, macula, optic disc, fovea, and blood vessels. The imaging of this area of the eye has undergone a revolution because of technological advancements, particularly deep learning.

Realistic image synthesis of the eye fundus was a very difficult undertaking prior to the development of deep learning techniques. As computing power has improved over time, machine learning in neural networks with extremely complex architecture is now possible. The development of DL makes GAN an important framework. The colored retinal fundus can be synthesized into realistic-looking images thanks to GAN. GAN is an unsupervised DL machine that Goodfellow first developed [33]. A generator and a discriminator are its two models. By selecting noise samples at random and creating images from those samples, the generative model may capture data distribution [34]. In order to distinguish between authentic and false images, the discriminative model is tasked with estimating the chance that a sample will come from the data distribution rather than the generator distribution.

GANs have shown the ability to generate stunningly accurate synthetic medical images. This section addresses current research on GANs for colored retinal fundus image synthesis. The vascular tree segmentation was combined with retinal fundus pictures. The U-Net architecture was used to create binary maps of the retinal vasculatures. Using an image-to-image translation method, the pairs were used to build a mapping from a binary vascular tree to a new retinal picture (512 X 512 pixels) [35]. A global L1 loss and a general GAN adversarial loss were used to handle the low-frequency information in the images generated by the generator. The Messidor-1 dataset provided 614 photo pairs for the training set. They used Qv scores and image structure clustering (ISC) scores, two no-reference metrics for retinal picture quality, to examine the quality of their manufactured results. The latter score was more concerned with the assessment of contrast surrounding vessel pixels, whereas the previous score was more thorough.

GANs have made tremendous progress in recent years, and interest in the synthesis of retinal images using GANs has recently increased. Using these tactics, it may be possible to overcome constraints such as the shortage of large, annotated datasets and the high cost of obtaining high-quality medical data. Legal difficulties with patient privacy and anonymized medical records could also be resolved using these producing techniques. However, GAN applications in medical imaging are constantly evolving, and the results are still far from clinically useful. Doctors rely largely on retinal images to convey critical information about a patient's health, so any synthetic production must be done carefully while keeping the specific structure of colored retinal fundus images into account. In conclusion, the versatility of GAN suggests that these can be applied to a variety of medical images with the goal of deploying these methodologies used for retinal synthesis [34].

5. CHALLENGES FOR GENERATIVE AI IN TACKLING RETINAL DISEASES

- A. Scarcity of dataset availability: Training in a computer-based algorithm requires a large amount of dataset, currently there are not enough datasets available for this purpose. Which makes it difficult for the machine to properly deliver its results. As the discriminator needs to find the patterns and be able to identify between right and wrong. This issue can be tackled by encouraging patients who can provide their dataset, monetarily or voluntarily, for the benefit of mankind.
- B. Patients' privacy: There are numerous regulations governing patient confidentiality. The application of generative artificial intelligence in healthcare poses additional concerns regarding the protection of patient privacy and sensitive medical data, as well as the possibility of misusing healthcare data or gaining illegal access to it [36]. Patients' privacy can be maintained through proper legislation by the government. However, these data can be shared with relevant authorities for study and research purposes.

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Study	Model/Architecture	Results
(Ce Zheng, Xiaolin Xie, Kang Zhou, 2020)	GAN was used to synthesize high images of the retina using a publicly available OCT dataset	For retinal specialists 1 and 2, the ability to distinguish between true and fake OCT pictures was 59.50% and 53.67%, respectively.
(Ce Zheng, Hongfei Ye, PhD, Jianlong Yang, 2022)	Utilized a supervised dataset of roughly 400 OCT images and an unsupervised dataset (107,912 unlabelled pictures). Automatic retinal disease detection from OCT pictures using semi-supervised GAN and a supervised DL model.	The model detected diabetic macular edema, drusen, and choroidal neovascularization. In terms of results in the area under the receiver operating characteristic curve, the semi-super- vised GANs classifier beat the supervised DL model (0.99 vs 0.97, 0.97 vs 0.96, 0.99 vs 0.99, respectively).
(Daniel Shu Wei Ting, Louis R Pasquale, Lily Peng, 2018)	Deep learning system in the detection of referable diabetic retinopathy by using Messidor-2 (test datasets) after investigating 1748 test images.	The area under the characteristic curve for the detection of referable diabetic retinopathy was 0.98 with sensitivity around 96.80pc and specificity around 87pc
(Bianca S. Gerendas, Amir Sadeghipour, Ursula Schmidt-Erfurth, 2018)	Deep learning is based on the convolutional neural network (CNN) paradigm. The patient dataset used here consists of around 4508 pictures.	Age-related macular degeneration with AUC around 0.98 with sensitivity around 96.80pc
(Amin Alqudah, Ali Mohammad, Ma'moun AlTantawi, 2021)	Linear Support Vector Machine (LSVM), Random Forest (RF), and Linear Discriminant Analysis (LDA) with a dataset of 137,437	The classifiers were able to classify the OCT images according to the specific order with Ann accuracy of 97.1pc

Table 1 – Results & Findings

6. RESULTS AND FINDINGS

7. CONCLUSION

No surprises Over the past few years, GANs have made enormous development, and the synthesis of retinal images using GANs has also attracted more attention. GANs provide a quick and high success rate even in dealing with and diagnosing the most complex part like the retina. The treatment of retinal diseases like DR, AMD, and Retinal Fundus has become very easy after ophthalmologists have shifted to GANs. However, there are many stumbling blocks in front of this success, lack of data availability and the issue of data privacy is the most notable of them. But these issues can be solved by proper discussion among all the relevant stakeholders. With all difficulties, the advantages of treating retinal disease with GANs outweigh its disadvantages. Thus, experts and ophthalmologists are needed to show some flexibility in this technology.

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34

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COMPUTER SCIENCE AND ARTIFICIAL INTELLIGENCE SESSION

NEXT-GENERATION FIREWALL AND ARTIFICIAL INTELLIGENCE

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Abstract:

As cyber threats evolve and become more sophisticated, the need for advanced network security solutions continues to grow. Next-Generation Firewalls (NGFWs) have emerged as a practical solution, utilizing Artificial Intelligence (AI) and Machine Learning (ML) algorithms to provide adaptive and intelligent protection against advanced cyber-attacks. This paper explores the development of NGFWs, their integration with AI and ML, and their impact on network security.

Keywords:

Evolution of Firewalls, Ngfws, Deep Packet Inspection, Intrusion Prevention Systems.

INTRODUCTION

Organizations have become more vulnerable to cyber threats due to increased dependence on digital technology. Traditional firewalls are no longer sufficient to counteract the rapidly changing landscape of cyber threats, and this has led to the development of Next Generation Firewalls (NGFWs), which incorporate advanced features such as deep packet inspection, intrusion prevention systems, and application awareness. Integrating Artificial Intelligence (AI) and Machine Learning (ML) in NGFWs has further enhanced their ability to detect and mitigate cyber threats. This paper discusses the development of NGFWs, their integration with AI and ML, and their impact on network security.

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2. NEXT-GENERATION FIREWALLS AN OVERVIEW

2.1. EVOLUTION OF FIREWALLS

Traditional or packet-filtering firewalls rely on static rules to filter traffic based on the source and destination IP addresses, protocol, and port numbers. However, as cyber threats grew more sophisticated, these firewalls became less effective, prompting the development of stateful firewalls. The emergence of web applications and the increasing use of encrypted traffic called for a more advanced firewall solution; this led to the development of NGFWs, which incorporated additional features such as application awareness, deep packet inspection, and intrusion prevention systems [1].

2.2. INTEGRATION OF AI AND ML IN NGFWS

AI and ML algorithms enable NGFWs to analyze and learn from network traffic patterns, identify anomalous behaviour, and adapt their security measures accordingly. This technology has significantly improved our ability to detect, prevent, and respond to cyber-attacks. As cyber threats evolve and become more sophisticated, we will likely see even more innovative applications of AI and machine learning in cybersecurity [2].

2.3. APPLICATIONS OF AI AND MACHINE LEARNING IN CYBERSECURITY

AI and machine learning are in various applications, such as tackling huge volumes of malware, detecting spam and business email compromises, analyzing network traffic, using facial recognition, and more. However, little evidence supports the belief that criminal cyber gangs are already using AI to help generate new malware strains. Evidence shows that artificial intelligence and machine learning are being used in other areas to circumvent protective security measures [3].

2.3.1. Generating deep fake videos and images to phish users and bypass security measures

Deep fakes can create fake identities on social media sites, making it more difficult for security measures to detect malicious activity. For example, an attacker could create a deep fake video of a CEO requesting sensitive information from an employee, tricking the employee into handing over the data [4].

2.3.2. Solving CAPTCHAs to bypass authentication protections

Attackers can use AI to solve CAPTCHAs, making it easier to carry out automated attacks against vulnerable targets.

They were gathering open-source intelligence on organizations to target attackers. AI and ML can collect information on organizations from public sources such as social media, news articles, and company websites. This information can craft targeted attacks against specific individuals or organizations [5].

2.3.3. Network traffic analysis

AI and machine learning can also analyze network traffic and identify patterns indicating a potential attack.

Zero-day attacks. AI and machine learning algorithms can detect anomalous behaviour within an application, which may indicate a zero-day attack [6].

2.3.4. Fraud detection

AI and machine learning algorithms can identify patterns and anomalies that may suggest fraudulent behaviour, such as credit card fraud, identity theft, and account takeover attacks [7].

2.3.5. Vulnerability assessment

AI and machine learning algorithms can identify potential weaknesses attackers may exploit by analyzing data from vulnerability scans and penetration tests [7].

2.3.6. Insider threat detection

AI and machine learning algorithms can identify behaviour indicative of an insider threat by analyzing data from various sources, including employee activity logs, network traffic, and social media activity [7].

2.3.7. Behavioural biometrics

AI and machine learning algorithms can create a unique behavioural profile for each individual based on data such as keystroke patterns, mouse movements, and mobile device usage, making it more difficult for attackers to impersonate legitimate users [8].

2.3.8. Threat intelligence

AI and machine learning algorithms can analyze large amounts of threat intelligence data to identify emerging threats and trends [2].

2.3.9. Cybersecurity risk assessment

AI and machine learning algorithms can help organizations identify potential weaknesses and prioritize their security efforts by analyzing data from various sources, including vulnerability scans, penetration tests, and employee activity logs [1].

2.3.10. Threat hunting

AI and machine learning algorithms can proactively search for threats within an organization's network.

2.3.11. Predictive analytics

AI and machine learning algorithms can predict future cyber-attacks by analyzing historical data and identifying patterns and trends.

2.3.12. Fraud prevention

AI and machine learning algorithms can prevent fraudulent activity before it occurs by analyzing data from various sources, including transaction logs, user activity logs, and social media activity [4].

2.3.13. Network anomaly detection

AI and machine learning algorithms can detect network anomalies that may indicate a potential attack.

2.3.14. Cloud Security

AI and machine learning algorithms can secure cloud-based applications and infrastructure.

2.3.15. Cybersecurity training

AI and machine learning algorithms can provide personalized cybersecurity training to employees.

3. EXPLORING THE KEY AI AND ML TECHNIQUES AND FEATURES OF NEXT-GENERATION FIREWALLS (NGFWS)

Integrating AI and ML algorithms in NGFWs has significantly enhanced their ability to detect and mitigate cyber threats. AI and ML techniques enable NGFWs to analyze large volumes of network traffic data, identify patterns and anomalies, and adapt their security measures accordingly.

3.1. SOME OF THE ESSENTIAL AI AND ML TECHNIQUES USED IN NGFWS INCLUDE:

3.1.1. Deep Packet Inspection

Deep packet inspection is a fundamental technique in NGFWs that enables them to inspect traffic beyond the traditional network and transport layer headers. This technique involves analyzing the content of packets at a granular level to identify threats, malicious payloads, and other security risks, and this allows NGFWs to detect and block various security threats, including malware, viruses, and intrusion attempts [2].

3.1.2. Behavioural Analysis

Behavioural analysis involves analyzing network traffic for patterns, trends, and anomalies that indicate potential security threats. This technique consists of monitoring network traffic and researching ways to identify anomalous behaviour indicative of an attack or security breach. NGFWs use machine learning algorithms to detect and analyze network traffic behaviour and identify potential security threats based on patterns that deviate from the norm [7].

3.1.3. Machine Learning

NGFWs use machine learning to detect and prevent security threats in real-time, such as identifying and blocking malicious traffic before it can reach its target. NGFWs use machine learning algorithms to analyze large datasets and identify patterns and anomalies that may indicate potential security threats. Machine learning algorithms can analyze large volumes of data and detect difficult or impossible patterns for humans [2].

3.1.4. Natural Language Processing

Natural language processing involves analyzing the content of network traffic to identify potential threats based on the language used, sentiment, and context. This technique analyses and understands network traffic's context and meaning to identify potential threats. This technique can identify social engineering attacks, such as phishing emails or spear phishing attacks [9].

3.1.5. Predictive Analytics

NGFWs use predictive analytics to anticipate potential security threats and take proactive measures to prevent them from occurring. Predictive analytics involves analyzing historical data to identify patterns and trends that may indicate potential security threats. NGFWs can use this information to predict future threats and take appropriate action to prevent them from occurring [6].

3.1.6. Threat Intelligence

Threat intelligence involves gathering information about potential security threats from various sources, such as security vendors, government agencies, and industry groups. NGFWs can use this information to identify and block known threats in real-time, improving their ability to detect and prevent security breaches. This technique involves using external sources of threat intelligence, such as threat feeds, to identify and block known threats [6].

3.1.7. User and Entity Behavior Analytics (UEBA)

UEBA analyzes user and entity behaviour to identify potential insider threats and security risks. UEBA involves analyzing user and entity behaviour to identify anomalies that may indicate potential security threats. NGFWs can use UEBA to identify potential insider threats, such as employees accessing sensitive data outside of regular business hours or attempting to access data they are not authorized to access [10].

3.1.8. Heuristics

NGFWs use heuristics to detect and block new and unknown threats based on their behaviour and characteristics. Heuristics involves analyzing the behaviour and characteristics of network traffic to identify potential threats based on patterns or signatures. NGFWs use heuristic analysis to detect threats not previously identified, such as new malware or zero-day attacks [6].

3.1.9. Anomaly Detection

This technique identifies network traffic that deviates significantly from normal behaviour, indicating a potential security threat. Anomaly detection uses statistical analysis to compare current network behaviour against historical data and predefined thresholds. An alert is triggered when network behaviour deviates significantly from the regular pattern, indicating a potential security threat [4].

3.1.10. Contextual Awareness

NGFWs use contextual awareness to understand the context in which network traffic occurs, such as the location of the user or device, to identify potential threats better. Contextual awareness involves analyzing the metadata associated with network traffic, such as the user's location, device type, and application. This information helps NGFWs identify potential security threats more accurately, as some behaviours may be considered normal in one context but abnormal in another [3].

3.1.11. Multi-Factor Authentication

Multi-factor authentication involves using two or more authentication factors to verify a user's identity. NGFWs use machine learning algorithms to identify patterns in user behaviour and determine if a login attempt is legitimate or fraudulent, helping to prevent unauthorized access. NGFWs use machine learning algorithms to detect anomalous login attempts, such as multiple failed attempts or attempts from unfamiliar devices, and take appropriate action, such as blocking the user or notifying an administrator [8].

3.1.12. Data Loss Prevention (DLP)

DLP techniques prevent the unauthorized transfer or exfiltration of sensitive data by analyzing network traffic for patterns that indicate potential data breaches. DLP involves scanning network traffic for sensitive data, such as credit card numbers, social security numbers, or intellectual property, and blocking or encrypting the data to prevent unauthorized transfer. NGFWs use AI and ML techniques to detect and classify sensitive data, even when it is obfuscated or disguised within other data [11].

3.1.13. Reputation Analysis

This technique involves analyzing the reputation of network traffic sources, such as IP addresses or domains, to identify potential threats based on their historical behaviour. Reputation analysis consists of gathering data on the historical behaviour of network traffic sources, such as the number of malicious or spam-related activities associated with an IP address or domain. NGFWs use this information to evaluate the risk associated with network traffic and take appropriate action, such as blocking traffic from high-risk sources [3].

3.1.14. Application Awareness

NGFWs provide deep application visibility and control, allowing administrators to identify and manage specific applications running on the network. Application-aware firewalls can recognize the application protocol and enforce policies based on application type, behaviour, or user identity. This feature allows organizations to identify and mitigate security risks associated with specific applications and prevent unauthorized access to sensitive data [3].

3.1.15. SSL Inspection

NGFWs can inspect SSL-encrypted traffic to identify and block potential threats hidden within the traffic. SSL inspection involves decrypting SSL traffic, analyzing it for potential hazards, and re-encrypting it before sending it to the destination. This feature is essential for preventing attacks that use SSL encryption to hide their activities, such as malware or phishing attacks [7].

3.1.16. Virtual Private Networks (VPN)

NGFWs often include VPN functionality, providing secure remote network access. VPNs allow remote users to connect to the network using an encrypted tunnel, providing a safe and private connection. VPNs are essential for remote workers, branch offices, and business partners to access network resources securely [7].

3.1.17. Intrusion Prevention System (IPS)

IPS systems are essential for protecting against various threats, including viruses, malware, and zeroday exploits. IPS functionality is often integrated into NGFWs to detect and block known and unknown attacks. IPS systems analyze network traffic in real-time, comparing it against available attack signatures and behavioural anomalies. If an attack is detected, the IPS can block the traffic, preventing the attack from reaching its target [6].

3.1.18. Web Filtering

NGFWs can filter web traffic based on categories such as productivity, social media, gambling, and others to prevent employees from accessing sites that are not work-related. Web filtering enables organizations to control web access and reduce the risk of security threats arising from unsecured websites or inappropriate content. It also helps to maintain productivity by reducing distractions and improper use of resources [6].

3.1.19. Centralized Management

NGFWs often include centralized management consoles, which enable administrators to configure, monitor, and manage firewall policies across multiple locations or devices from a single interface. Centralized management provides a holistic view of network traffic, simplifying the management of security policies and reducing the risk of errors or inconsistencies in the policy application [6].

3.1.20. Advanced Threat Protection

NGFWs often include advanced threat protection features such as sandboxing, threat emulation, and threat extraction to detect and prevent sophisticated attacks. These features use advanced AI and ML techniques to identify and analyze potential threats, providing a more comprehensive level of protection. Sandboxing, for example, isolates unknown files in a virtual environment to test their behaviour and identify any malicious activity [10].

In summary, these features are critical to the effectiveness of NGFWs in detecting and preventing a wide range of known and unknown security threats. AI and ML techniques in NGFWs enable organizations to detect and respond to security threats more quickly and effectively, improving their overall security posture.

Furthermore, as cyber threats evolve, organizations must adopt and utilize NGFWs with advanced AI and ML capabilities; this will not only improve their ability to detect and prevent cyber attacks but also help them stay ahead of the latest threats. Ultimately, investing in NGFWs with advanced AI and ML techniques is an investment in the security and resilience of an organization's network infrastructure.

4. CHALLENGES AND FUTURE PROSPECTS OF AI-ENABLED NGFWS

Implementing AI and machine learning algorithms in Next Generation Firewalls (NGFWs) has significantly enhanced their ability to detect and mitigate cyber threats. However, several challenges must maximize the benefits of these technologies.

Data privacy and legal concerns are among the primary challenges of implementing AI and ML algorithms in NGFWs. These algorithms require access to vast network traffic data, which may include sensitive information. This raises concerns about data privacy and potential violations of data protection laws.

The computational complexity of AI-enabled NGFWs is another significant challenge. Implementing machine learning algorithms can increase computational complexity and resource consumption, impacting network performance. Adversarial attacks are also a significant challenge for AI-enabled NGFWs. Cybercriminals may use malicious machine learning techniques to evade NGFWs, creating new network security challenges.

The need for the explainability of AI-enabled NGFWs is another challenge. Machine learning algorithms can make decisions based on complex models that are difficult to understand or interpret. This lack of explainability can make troubleshooting or identifying the cause of security issues challenging.

Training data is also a significant challenge for AIenabled NGFWs. The accuracy and effectiveness of machine learning algorithms depend on the quality of the training data used. However, training data may need to be completed, leading to accurate or complete security decisions.

Integrating AI-enabled NGFWs with legacy systems can also be a challenge. Legacy systems may need to be compatible with the latest AI and machine learning technologies, making it challenging to implement NGFWs effectively.

High cost is another challenge for AI-enabled NGFWs. They may require significant hardware, software, and professional personnel investment, making them cost-prohibitive for some organizations.

Finally, using AI and ML in NGFWs raises ethical concerns, such as potential discrimination or bias against certain groups or individuals. Organizations must ensure that their AI-enabled NGFWs are designed and implemented ethically and responsibly.

5. PROSPECTS OF AI-ENABLED NGFWS

Despite the challenges, AI-enabled NGFWs hold great promise for the future of network security. These technologies offer several benefits, including [12]:

- Enhanced threat intelligence sharing: With AI and ML algorithms, NGFWs can analyze vast amounts of threat data from various sources, identify commonalities and patterns, and share this information with other NGFWs and security vendors. This can lead to more effective collective security, helping organizations to stay one step ahead of cyber attackers.
- Improved network visibility: AI-enabled NGFWs can analyze encrypted traffic to identify anomalies and detect threats that may be hidden within encrypted communication. This can lead to more effective threat detection and prevention measures and help organizations protect their sensitive data better.
- Autonomous security solutions: Developing AI and ML algorithms may pave the way for fully autonomous network security solutions. These autonomous security systems would detect and respond to threats in real time without human intervention, potentially reducing the risk of human error and improving overall security posture.
- More accurate threat detection and prevention: AI and ML-enabled NGFWs offer more accurate threat detection and prevention, adaptive security that can adjust to changing threat landscapes, cost savings through reduced reliance on human intervention, and improved compliance with regulatory requirements.
- Advanced Behavioral Analysis: AI and ML algorithms have the potential to provide advanced behavioural analysis of network traffic, allowing NGFWs to detect and prevent threats based on anomalous behaviour.
- Predictive Analytics: NGFWs can analyze vast amounts of data to identify patterns and predict future threats, allowing them to take proactive measures to prevent attacks before they occur.

- Quantum Computing: NGFWs can harness the power of quantum computing to improve their threat detection and prevention capabilities, allowing them to analyze vast amounts of data quickly and accurately.
- Cybersecurity Ecosystems: AI and ML technologies can help NGFWs collaborate and share threat intelligence with other security systems, developing interconnected cybersecurity ecosystems.
- Immersive Technologies: Immersive technologies such as virtual and augmented reality can provide real-time visualization and network traffic analysis, allowing security professionals to quickly identify threats and take appropriate action.
- Explainable AI: Explainable AI refers to the development of transparent AI algorithms that can explain their decision-making process, making it easier to refine the NGFW's rules and policies for more effective threat detection and prevention.
- Edge Computing: NGFWs could be deployed on edge devices such as routers and switches, allowing real-time threat detection and prevention at the network's edge.
- Cybersecurity as a Service: AI and ML technologies in NGFWs could enable the development of cybersecurity as a service (CSaaS) offerings, providing NGFWs with AI and ML capabilities to detect and prevent threats.
- Privacy-Preserving Technologies: Privacy-preserving technologies such as homomorphic encryption could ensure that sensitive data remains encrypted even when AI and ML algorithms are processed in NGFWs.
- Biometric Security: NGFWs could incorporate biometric authentication methods such as fingerprint or facial recognition to improve access control and prevent unauthorized access to the network.
- Adversarial Machine Learning: Adversarial machine learning involves designing AI and ML algorithms to be robust against attacks that aim to manipulate their decision-making process.
- GANs for Network Security: GANs could generate synthetic network traffic that mimics real traffic, allowing NGFWs to test and refine their threat detection and prevention capabilities more effectively.

- Swarm Intelligence: AI algorithms inspired by the behaviour of natural swarms could design AI algorithms that are more adaptive and flexible, allowing NGFWs to respond quickly to new and emerging threats.
- Memory-Augmented Neural Networks: Memory -augmented neural networks (MANNs) could enable NGFWs to learn from past threats and use this knowledge to detect and prevent future threats more effectively.
- Hybrid AI Algorithms: Hybrid AI algorithms could enable NGFWs to detect and prevent threats by leveraging the strengths of different AI algorithms more accurately.

6. CONCLUSION

Integrating AI and ML algorithms in NGFWs has significantly enhanced their ability to detect and mitigate cyber threats. Despite the challenges associated with data privacy, legal concerns, computational complexity, and adversarial attacks, AI-enabled NGFWs hold great promise for the future of network security. Improved threat intelligence sharing, enhanced network visibility, and the potential for autonomous security solutions are just some of the exciting prospects that lie ahead. As cyber threats evolve, AI and ML's ongoing development and integration in NGFWs will ensure robust protection for organizations worldwide.

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COMPUTER SCIENCE AND ARTIFICIAL INTELLIGENCE SESSION

HEAT FLOW PROCESS IDENTIFICATION USING ANFIS – GA MODEL

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Abstract:

This paper provides a nonlinear technique that uses a fuzzy inference system and neural networks for the identification purposes of heat flow transfer in the chamber. Firstly, linear models are obtained by transfer functions with delay using Matlab identification tools for heat exchange. Three different transfer functions are provided (for three sensors in different positions along the chamber), and after it has been concluded that the second model has the smallest error, it is tested using different input. In this case, the linear model failed to represent the behaviour of the system precisely, making the error more than 1.5 C in the steady state. This was expected because linear models are trustworthy only around certain operating ranges. In order to make the new model, which will be unique and valid in the whole state space, another identification method using an adaptive neuro-fuzzy inference system (ANFIS) was presented. Furthermore, for the best performance, the ANFIS architecture was found using one of the most famous population-based optimizations: the genetic evolutionary algorithm. With two inputs and 70 parameters found by optimization (40 premises and 30 consequent) ANFIS greatly outperforms standard identification technique in terms of the mean square error. This nonlinear model was also tested on the different input, which was not used in the training process, and it was concluded that the nonlinear model identifies the real object with a neglectable error, which is 45 times smaller than the linear one.

Keywords:

ANFIS, Genetic algorithm, Identification, Optimization, Heat flow process.

INTRODUCTION

Precise temperature control is required in many processes in different industries, such as metalworking, oil refining, food processing, petro and biochemical industries, fabrication of microelectronic devices, as well as scientific applications. Effective heating, ventilation, and air conditioning (HVAC) systems in those industries mostly depend on heat transfer. Accurate heat transfer models can help researchers and engineers to understand the physical mechanisms in the energy conversion processes and to improve the efficiency of potential controllers.

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e-mail: mvesovic@mas.bg.ac.rs System identification is an essential tool in the process of creating a mathematical model that accurately represents the behaviour of a physical system based on experimental data. Such models are very important especially when mathematical relations between input and output are not known or when they are so complicated that they cannot be simply expressed and understood. In order to capture all of the complexity, identification implies the collection of experimental data that describe the behaviour of the system under certain conditions, and if the model that has been created is reliable, it will be able to predict the output of the system not only under the circumstances in which the data was recorded, but also under various other unknown conditions.

As the identification of heat transfer in a room or chamber is essential for designing an efficient HVAC system, some papers have already investigated this subject using computer vision: [1], a pure time delay model with fractional order pole [2], or the Takagi-Sugeno fuzzy model [3].

Various techniques and their combinations for identification purposes, that are used today, can be found in the literature. There have been an increasing number of papers in recent years in which artificial intelligence, fuzzy logic, machine learning, and optimization algorithms appear. These newer methods are often compared with some traditional, linear, or analytical models for identification. In [4] Authors proposed an approach where both - the premise and consequent parameters are updated using Genetic Algorithm (GA) and tested it on a simple pendulum, swinging through a small angle, which has been considered as a nonlinear dynamic system identification problem. It was discovered that using GA to optimize ANFIS parameters is more successful than other methods. Authors in [5] also compare ANFIS – GA along with other identification methods and prove its superior characteristics, for pendulum and two more different systems. Finally, the reliability of this method was proven in a paper [6] where the symbioses of ANFIS and a genetic algorithm for brain tumor image classification are explored and satisfactory results are proven in terms of sensitivity, specificity and accuracy.

Metaheuristics include abstract stochastic optimization method, that are often used in many constrained and unconstrained nonlinear system issues [7]. In this paper, system identification will be done using linear (timedelayed transfer functions) and nonlinear (Adaptive Neuro-Fuzzy Inference System optimized with a genetic algorithm) methods.

2. SYSTEM DESCRIPTION

Figure 1 shows the Quanser Heat-flow experiment (HFE) [8]. The system is basically an advanced rheostat, which consists of an aluminium plate, that includes a blower, a coil-based heating device, and three temperature sensors evenly spaced along the conduit. The thermocouples measure the temperature at different locations on the plate. All three sensors are fast-setting platinum transducers. The blower's tachometer is used to measure the fan speed. The delivered power is controlled by analog signals and the data obtained from the thermocouples is collected and analysed using Quanser's software.



Figure 1 – The setup for Heat Flow Experiment [8].

3. LINEAR MODEL IDENTIFICATION

An open-loop experiment is carried out in order to identify the mathematical representation of the heat flow system. In this experiment, the blower and heater voltages are applied, and three temperature sensors are used to measure the corresponding chamber temperatures. Five seconds into the beginning of the experiment, a 5 V step signal is introduced. The blower input voltage stays at 3 V throughout the whole operation. After 120 seconds, the experiment automatically stops. Due to its proximity to the heater and blower, sensor 1 shows a faster rise in temperature than sensors 2 and 3. Consequently, the rate of temperature increase varies along the chamber. Three models are created, one for each sensor's temperature reading and heat flow step responses are consistent with the identified first-order transfer functions with delay, Equation 1. The linear models are obtained using Matlab identification tools (simplified refined instrument variable (IV) method SRIV, the state variable filter SVF approach and the generalized Poisson moment function GPMF) [9].

$$W_{1}(s) = \frac{0.2523}{s + 0.03563} e^{-0.198s}$$
(1)

$$W_{2}(s) = \frac{0.137}{s + 0.03107} e^{-0.396s}$$
 (2)

$$W_{_3}(s) = \frac{0.1458}{s + 0.03242} e^{-0.594s}$$
(3)



Figure 2 shows the step responses of these models and the following Table 1 is used to assess the quality metrics of the obtained models for sensor 1 (S1), sensor 2(S2) and sensor 3(S3): Fit to estimation data (FIT) - the fit value between the 1-step ahead predicted response of this model to measured data, also called (prediction focus); Final prediction error (FPE) - a measure of model quality by simulating the situation where the model is tested on a different data set and Mean square error (MSE) [10].

Table 1 – Quality metrics of the obtained linear models

	S1	\$2	\$3
FIT	95.80%	95.50%	95.77%
FPE	0.1874	0.08602	0.08171
MSE	0.2096	0. 0949	0.1349



Figure 2 - Comparison: linear model and real output.

46

SINTEZA 2023

4. ANFIS

The extraordinary machine learning model known as the Adaptive Neuro-Fuzzy Inference System, or ANFIS for short, combines the advantages of fuzzy logic and neural networks to produce a hybrid system that is capable of producing precise predictions and classifications. The identification and control of complex systems, as well as image processing, are just a few of the many areas in which the ANFIS model has been used.

The manner in that ANFIS corrects for model inaccuracies using fuzzy if-then rules learned from inputoutput data is what makes it so effective. The neural network element of ANFIS modifies the fuzzy sets and operator settings to increase prediction accuracy. Backpropagation, a gradient descent algorithm used to reduce the difference between forecast and actual outputs, is typically used for this purpose.

The power of ANFIS to manage nonlinear interactions between input and output variables is one of its key advantages. This is so that complicated interactions and nonlinearities can be captured by the fuzzy sets used to represent the inputs and outputs. Additionally, the neural network element of ANFIS can be trained to change the parameters of the fuzzy sets and operators, enhancing the data's fit and producing predictions that are more precise.

The ANFIS model (with two input variables) consists of five layers, which are:

• Input Layer: This layer on the output gives the degree of membership for the corresponding membership function. All of the nodes have adaptive character, so the shape of the membership function can be changed during training. Each input node represents one input variable and passes the input value to the next layer:

$$O_{i}^{1} = \mu_{A_{i}}(x_{1}), O_{i+2}^{1} = \mu_{B_{i}}(x_{2}), i = 1, 2.$$

Equation 2 – The first layer output.

 μ_{A_i} and μ_{B_i} represent membership functions for *i*=1,2. Gaussian or bell-shaped membership functions are most often encountered in the literature, and many others have been tried as well. For example, the Gaussian membership function is given by two parameters as:

$$G(x,a,\beta) = e\frac{(x-c)^2}{2\sigma^2}$$

Equation 3 – Gaussian membership function.

• Fuzzification Layer: Unlike the previous layer, the nodes of the second layer are fixed. The output from the node represents the firing strength of the rule *w_i*. A large firing strength indicates that the rule is more dominant in deciding the final output.

$$D_i^2 = w_i = \mu_{A_i}(x_1) \cdot \mu_{B_i}(x_2), i = 1, 2.$$

Equation 4 – The second layer output.

• Rule Layer: As well as the previous layer, this layer consists of fixed nodes. Each node in this layer corresponds to one rule and combines the membership values from the fuzzification layer to produce the firing strength of the rule. The firing strength of a rule represents the degree to which the input values satisfy the conditions of the rule.

$$O_i^3 = \overline{w}_i = \frac{w_i}{w_1 + w_2}, i = 1, 2.$$

Equation 5 – The third layer output.

• Defuzzification Layer: This layer consists of nodes that combine the firing strengths of the rules to produce a crisp output value. There are different defuzzification methods that can be used, such as the centre of gravity method or the weighted average method.

$$O_i^4 = \overline{w}_i f_i = \overline{w}_i \left(p_i x_1 + q_i x_2 + r_i \right)$$

Equation 6 – The fourth layer output.

 $\{p_{i}, q_{i}, r_{i}\}$ is a set of the consequent parameters.

• Output Layer: This layer consists of a single node that represents the output variable of the system. The output node receives the crisp output value from the defuzzification layer and produces the final output value.

$$O_i^{s} = y = \sum_i \overline{w}_i f_i = \frac{\sum_i w_i f_i}{\sum_i w_i} = (\overline{w}_1 x_1) p_1 + (\overline{w}_1 x_2) q_1 + \overline{w}_1 r_1 + (\overline{w}_2 x_1) p_2 + (\overline{w}_2 x_2) q_2 + \overline{w}_2 r_2$$

Equation 7 – The fifth layer output.

The ANFIS structure contains two groups of parameters: premise parameters and rule consequence parameters. Training the ANFIS network involves determining these parameters using an optimization algorithm, and since the first development of ANFIS, different training approaches have been proposed: derivative-based (gradient), heuristic and hybrid. One optimization algorithm can be used to set all parameters, or the parameters in the premise of ANFIS are set by one algorithm, and the parameters of the consequence by another algorithm. When using one of the gradient algorithms, there is a risk of getting stuck in a local minimum, and this is exactly what paved the way for metaheuristic algorithms [11]. An extensive review of the recent literature shows that metaheuristic algorithms are far more common than gradient algorithms and that their number is still growing Figure 3 [11]. The most well-known and most frequently used are Genetic Algorithm (GA) and Particle Swarm Optimization (PSO), as well as optimization based on the movement of grey wolves (GWO) and whales (WOA), differential evolution (DE), harmony search (HS), firefly algorithm (FA), mine blast algorithm (MBA), cuckoo search (CS) and artificial bee colony (ABC).



Figure 3 -The ratio of representation of metaheuristic algorithms in hybrid ANFIS structures (right). Percentage of papers on KOBSON when ANFIS and metaheuristic algorithms are keywords (left) [11].



Figure 4 - Flow chart of Genetic algorithm.

5. GENETIC ALGORITHM

Genetic algorithms are an optimization technique used to solve nonlinear or nondifferentiable optimization problems. They use concepts from evolutionary biology to search for a global minimum - an optimization problem. The name genetic algorithm comes from the fact that this method mimics evolutionary biology techniques, by starting with an initial generation of candidate solutions that are tested against the objective function. Secondly, the subsequent generations of points from the first generation are generated through things such as selection crossover and mutation. The selection retains the best-performing parent from one generation to the next, i.e. if there are parent 1 and parent 2, and these are the values of the variables in the optimization problem from the previous generation, they will make it through to the next generation just because they performed well in the previous generation through selection. Because they performed well, they might also be used for crossover, where common similarities between the different parent variables will be selected. Keeping those similarities will enable the algorithm to create children variables that will be in the next generation.

The genetic algorithm, as one of the first populationbased stochastic algorithm, has been successfully applied in various fields and its flowchart can be seen in Figure 4. All additional information can be found in [12].

6. NONLINEAR MODEL IDENTIFICATION

As sensor 3 output a signal that is too noisy, and sensor 1 has a larger error than sensor 2, the transfer function describing the system is chosen to be the one obtained from sensor 2 (s2). This sensor is in the middle of the chamber and according to the Table 1 mean square error of the transfer function obtained with this sensor is the smallest in relation to the actual behaviour of the object. A second transfer function from Equation 1 has been chosen, and a comparison has been made between the model and the real object, but with a different output signal (this time, five seconds into the beginning of the experiment, a 3V step signal is introduced). As can be seen from Figure 5, the mean square error, in this case, is much higher and amounts to 0.4495. The difference between the model and the real output signal is about 1.5°C in a steady state, and it has the tendency to grow as we go further from the original identification point. For precise industries, this can cause enormous problems. It is concluded that when changing the input, this model (blue line) is not suitable for the representation of the system (red line).

This is expected because the linear model is only valid around a certain point. In order for there not to be an infinite number of points (and therefore an infinite number of models), ANFIS is extremely suitable. Such a model would potentially be valid for the entire state space, and the end result would actually be only one model. In the previous section, two groups of parameters that can be updated (premise and consequence) were shown, and in this section, that update will be clarified. The objective is to determine the best values for these parameters that reduce the difference between the output of the ANFIS model and the desired output for a certain set of input data.

Since, in this paper, ANFIS uses Gaussian membership functions from Equation 3, the premise parameters are denoted as oi (the standard deviation) and ci (centre). The sum of the parameters in all member functions makes up the total number of underlying parameters. In this paper, the total number of premise parameters is 40 (2 inputs, 10 Gaussian membership functions with 2 parameters). Furthermore, it is clear from the defuzzification layer, Equation 7, the consequent parameters are denoted with pi, qi, and ri. The ANFIS structure in this paper has a total of 30 consequent parameters (because there are 3 parameters for each rule, and there are 10 rules in total). So, in summary, there are a total of 70 parameters that need to be optimized, using the GA metaheuristic approach, in the provided ANFIS architecture. The effectiveness of an ANFIS model on a certain data set should be assessed by the fitness function, and in this paper, the mean squared error is used, as one of the most common functions and in order to make the comparison with the linear identification.



Figure 5 - Comparison linear model and real object for s2 and input signal 3V.

Just for comparison purposes, first, the ANFIS model was trained with the same voltage values as in Figure 2 (after five seconds, a 5V step signal is introduced and the blower input voltage stays at 3V the whole experiment) for s2. Results can be seen in the next Figure 6, where behaviour of the real system is noted in green, linear model in blue and ANFIS in red line. Mean square error of the ANFIS model is equal to 0.0011945, and MSE of the linear model is significantly higher (it can be found in the second column, third row, in Table 1 for sensor 2) and is 0.0949.

Furthermore, another experiment is done. The ANFS model was created using different input voltages: 1.5V, 2V, 3V, 3.5V, 4.5V, and 5V (while the blower input voltage stays at 3V), and it was tested for an input it was not trained on: 4V. The same input was provided for the linear model with the second transfer function in Equation 1. Figure 7 shows the model performances in this case, and the mean square error for the ANFIS model is 0.009864.



Figure 6 - Comparison: Linear VS ANFIS model.



Figure 7 - Linear VS ANFIS model for input signal 4V.

50

7. CONCLUSION

After experiments presented in this paper, it is easy to notice that the ANFIS nonlinear identification method has shown superiority over standard identification. This is because the standard method uses the linear model with transfer function and delay, which will operate only around a certain point. On the other hand, ANFIS is capable of handling highly nonlinear systems with multiple inputs and outputs, which allows it to model more complex systems. This flexibility is not possible with the standard linear model, and it is crucial for decision-making in complex systems. Hence, it can be concluded that ANFIS can adapt to changes in the system and, moreover, it can handle noisy data and fully follow the dynamics of the system. ¬The model made by ANFIS will be more accurate and efficient compared to the basic ones, even in cases when the input is set to be a voltage that has not been used for training.

In order to guarantee the best performance, parameters for such an ANFIS model (premise and consequent) are found using one of the well-known metaheuristic method: genetic optimization algorithm, which is the first population-oriented stochastic algorithm. The fitness function is set to be the mean square error. Further research will be based on comparing different metaheuristic algorithms and maybe different kinds of optimization - not only parameters, but also the number of rules. Also, it is possible to change membership functions in ANFIS and make a comparison between a few different ones.

8. ACKNOWLEDGEMENTS

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COMPUTER SCIENCE AND ARTIFICIAL INTELLIGENCE SESSION

APPLICATION OF CONVOLUTIONAL NEURAL NETWORKS FOR THE CLASSIFICATION OF HUMAN EMOTIONS

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Abstract:

Computer vision training is implemented using deep learning. Deep learning can be applied to solve a variety of classification problems. Accordingly, the problem of recognizing human emotions based on facial images can be singled out. For this problem, the use of convolutional neural networks proved to be the best solution. Specifically, the convolutional neural network models used in this paper are ResNet50, VGG16, and VGG19. The CNN model was implemented using the Keras library and the Python programming language. As input to these models, the RAF-DB database containing images of human faces with emotions was used. Based on the results obtained from the mentioned three CNN models, VGG16 proved to be the best, achieving a precision of 83.61%. VGG19 was on the second place with an accuracy of 82.37%, and the worst was ResNet50, whose accuracy was 75.31%.

Keywords:

Convolutional Neural Networks, classification problems, RAF-DB, CNN models.

INTRODUCTION

People rely on the sense of sight and use it to get to know and analyze the environment. The eye captures images of the environment and sends them to the brain for processing. The eye can be treated as a sensor that is responsible for collecting information in the form of an image and further sending it to the brain, which can be treated as a computer. In this way, we arrive at the field of artificial intelligence called computer vision. This field allows computers to extract meaningful information from digital records (images, videos, etc.) and take specific actions or provide recommendations based on them. Artificial intelligence provides computers with the ability to think (form conclusions, make decisions, etc.), while computer vision enables the sense of sight (observation, understanding of the environment, etc.). To compensate for the lack of years of experience that the human eye has, computers use cameras, large data sets, various demanding algorithms, etc. Computer vision training is implemented through deep learning.

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Some enviable results have been achieved [1][2] when solving problems such as the recognition of various objects such as faces, diseases, etc. The problem of recognizing human emotions can also be singled out. This problem boils down to viewing images of human faces, detecting facial expressions, and classifying them according to the corresponding emotions. Deep learning uses convolutional neural networks (CNNs) that are suitable for solving this type of problem. The focus will be on the application of three existing CNN models on a set of images of human facial expressions and the analysis of the obtained results.

2. DEEP NEURAL NETWORKS

Deep learning is constantly changing. In recent years, significant advances have been made that have established artificial intelligence (and therefore deep learning) as one of the most promising areas of study. At the time of writing, one of the main types is convolutional neural networks [3].

2.1. CONVOLUTIONAL NEURAL NETWORK (CNN)

They are inspired by the biological nervous system and consist of different layers, where each layer has a certain number of neurons. Nodes are interconnected so that the output of a node from a layer represents the input of a node in the next layer. One of the earliest works related to the use of CNNs was published in 1998 [4], where a simple LeNet-5 model was presented that enables the extraction of simpler features of data and their aggregation, thus obtaining more complex features of data. The training process of the used CNN model was carried out using the MNIST database [5].

2.2. STRUCTURE

CNN consists of a part for extracting features (learning properties) of the input data and a part for determining the appropriate class to which the input data belongs (solving the classification problem). Both parts are built from special elements of CNNs called layers. The structure of the CNN model is given in Figure 1.



Figure 1 - The structure of the CNN model [6].

By setting the vehicle image is input to the CNN model, the learning of the features occurs which includes a combination of convolutional and pooling layers. One of the most common activation functions used is the Rectified Linear Unit (ReLU) [7]. The pooling layer allows the combining of several values into one. The second part of the CNN model is related to classification and consists of flattening and dense layers and an activation function. When it comes to solving a problem where more than two classes occur, the softmax activation function is used [8]. The focus will be on the following layer groups [9]: main, convolutional, pooling, regularization, and reshaping.

From the group of main layers, the dense layer was used to connect neurons between different layers. The output of one neuron from the previous layer represents the input of all neurons from the next layer. Convolutional layers refer to the extraction of the input data features and are used in combination with pooling. Convolution represents the use of filters of certain dimensions, with the desired step, to perform a more detailed analysis of the input data. There are various ways of pooling, the most used approach being maximum pooling where a 2x2 filter is used which passes the obtained data and returns the maximum value covered by the filter. Among the regularization layers, the dropout cancels out the contribution of some randomly chosen neurons. Randomly switching off neurons is used to reduce the possibility of overfitting the CNN model. The most used layer from the reshaping group is the flattening which performs the conversion of all resulting two-dimensional arrays into a single linear vector.

2.3. THE WORKING PRINCIPLE

Input data must be provided for the CNN model which is further sent into a feature learning section. Filters in convolutional layers represent a small matrix or an activation function that serves to detect features. A filter is placed on the input image and the shaded elements are multiplied with the corresponding filter elements and summed up. By passing the filter through the entire image with a given step, an activation map is obtained. In the pooling process, a 2x2 filter is most often applied. The maximum pooling approach looks at the values covered by the filter size and selects the largest one. This approach is repeated until all activation map values for each image have been passed. The part for learning the features of the input data ends here if there are no more convolutional and pooling layers. This whole process is demonstrated through an example in Figure 2.

Furthermore, the flattened data enters fully connected layers. The first fully connected layer accepts this data and must consist of as many neurons as there are flattened data. After that, the model is trained through these layers, i.e. adjustment of weight and bias coefficients to minimize the loss function. Based on these coefficients and using activation functions f (most often ReLU), the value of each neuron can be calculated as shown in Figure 3:

For model prediction, the class with the highest neuron value is taken. However, the training of the model is done through epochs where the model should give the best possible results through each iteration. This is done by modifying the weight and bias coefficients through a process called backpropagation. The main idea behind this is to go back and analyze the obtained neuron values and coefficients. If the obtained prediction is wrong, the neurons and coefficients that influence that prediction are reduced or increased to minimize the loss function. The training stops at the moment when the coefficients can no longer be corrected. If the model did not achieve satisfactory accuracy, it is necessary to review the model, as well as the input data.



Figure 2 - Convolution, pooling, and flattening process.



Figure 3 - Calculating the value of neurons.

3. CNN MODELS FOR THE CLASSIFICATION OF HUMAN EMOTIONS BASED ON FACIAL EXPRESSION IMAGES

In this chapter, the CNN models that were used to solve the mentioned classification problem are presented. The practical part requires the implementation of these models which was achieved by using Python libraries.

3.1. CNN MODELS

ResNet50, VGG16, and VGG19 were chosen because they are established as reliable and widely used, but also because of their availability within the Keras library. Residual Network (ResNet) is a CNN model developed by Microsoft [10]. This model can vary with the number of residual blocks they consist of. A residual block is a set of multiple layers in a model. The most used variation is the ResNet50, which consists of a total of 50 layers. ResNet152 is the first model of its kind to receive much attention. The reason for this is their victory at the ILSVRC competition, which took place in 2015, where it achieved an impressive error in image classification, which was only 3.6% [11]. In a network with residual blocks, the output from each layer is sent as input to the next layer and directly to layers separated by usually 2 or 3 layers (skip connections). This approach made it possible to solve existing problems of vanishing gradient and degradation problems [12] [13]. A new group of models was developed by the Visual Geometry Group (VGG) at the University of Oxford [14]. This group was first presented to the public at the ILSVRC competition in 2014, where it finished second [15]. This is certainly an enviable result if we take into account that they achieved a classification error of 7.3%, while in the first place, that error was slightly smaller and amounted to 6.7%. VGG models, although based on the AlexNet model [16], have several differences that set them apart from other models. Instead of using large receptive fields like AlexNet (11x11 with step 4), VGG uses very small receptive fields (3x3 with step 1). Stacking several smaller receptive fields gives better results than using a larger receptive field [14]. They consist of fewer parameters compared to the AlexNet model, which results in saving resources during training. The main two representatives of this group are the VGG16 and VGG19. The numbers 16 and 19 refer to the number of weighted layers. This means that VGG19 contains three more weighted layers compared to VGG16.

3.2. IMPLEMENTATION OF THE CNN MODELS

CNN models can be implemented using different programming languages and various libraries. However, within Python, two libraries have stood out and become the most used in this domain: TensorFlow [17] and Py-Torch [18]. For easier work with CNNs within Tensor-Flow, the Keras [19] library appears. TensorFlow is used to solve a variety of machine learning problems, while the Keras library specializes in deep neural networks. From Keras version 2.4 onwards only TensorFlow is officially chosen as the default library for backend work. Keras library provides rapid experimentation with deep neural networks, ease of use, modularity, and extensibility.

4. PREPARATION OF THE CNN MODELS AND DATASET

The focus will be on explaining a key concept called transfer learning. This concept allows faster training of CNN models, which further provides easier experimentation with the model. Also, it is necessary to review the images and consider whether the set is adequate for use and whether any improvement can be made.

4.1. TRANSFER LEARNING IN CNN MODELS

Transfer learning has become widely represented in CNNs. The idea is to transfer the knowledge of an already trained CNN model. Mostly known CNN models are trained using more than one million images from the ImageNet [20]. That knowledge can be used as a basis for further training and solving some other classification problems. Transfer learning significantly reduces the training time because it is not necessary to train the model from the beginning. Within the Keras library, 38 CNN models can be used [21]. It is possible to set initial weights for these CNN models. These weights are important because they are treated as the knowledge of the model. The weights can be adjusted by loading the weights that were formed during the training on the ImageNet database. This means that CNN models are pretrained and ready for use. There are two strategies with which it is possible to train CNN models and apply the concept of transfer learning: feature extraction and fine-tuning [22].

4.2. DATASET OF FACIAL EXPRESSION IMAGES

The main difficulty that can arise is finding an adequate database which means that it is large enough and that the data is correct. A large number of databases are available on the Kaggle [23], although for some it is necessary to contact the creators of those databases. In this paper, RAF-DB (Real-world Affective Faces Database) [24] was used. It presents a large set of images with various facial expressions collected from the Internet including the following emotions: anger, fear, happiness, neutrality, sadness, surprise, and disgust. Due to the very small number of images within the disgust emotion, this class was discarded. The classes and the number of images are given in Figure 4.

Data augmentation can be applied to this set of images. Augmentation is performing various transformations on data. By applying augmentation, a larger dataset is obtained. Due to the already edited images in the dataset (cropped images of facial expressions, centered facial expressions, solid brightness, etc.), the only transformation that is used is the horizontal rotation of the image.

5. COMPARISON AND ANALYSIS OF THE RESULTS FOR THE CLASSIFICATION OF HUMAN EMOTIONS USING CNN MODELS

In this classification problem, three CNN models were considered, namely: ResNet50, VGG16, and VGG19. The RAF-DB dataset is divided into a set of images for training (80%) and a set of images for validation (20%). During the training and validation of the CNN model, the accuracy and losses are recorded for each of the epochs. The accuracy of the CNN model represents the ratio between the number of correct predictions and the total number of predictions. Loss measures the errors that occur in predictions and the goal is to minimize it. Various functions can be used to measure losses, and here categorical cross-entropy was used.

5.1. RESNET50 MODEL RESULTS

The ResNet50 model reached saturation after eight epochs, and after that, the training and validation of the model were completed. The accuracy and losses of the model during training and validation are shown in Figure 5.



Figure 4 - Structure of the dataset.





56

Model training and validation are stopped at the end of the eighth epoch because model saturation occurs (accuracy and losses converge). The final values are given in Table 1.

Table 1 - Results for the accuracy and losses of the ResNet50 model in the last epoch.

Last	Training	Training	Validation	Validation
epoch	(Loss)	(Accuracy)	(Loss)	(Accuracy)
8	0.1378	0.9584	0.8893	0.7531

Model training and validation are stopped at the end of the eighth epoch because model saturation occurs (accuracy and losses converge). The final values are given in Table 2.

Table 2 - Results for the accuracy and losses of the VGG16 model in the last epoch.

Last	Training	Training	Validation	Validation
epoch	(Loss)	(Accuracy)	(Loss)	(Accuracy)
11	0.1785	0.9388	0.5602	0.8361

5.2. VGG16 MODEL RESULTS

The VGG16 model reached saturation after eleven epochs, and then the training and validation of the model were completed. The accuracy and losses of the model during training and validation are shown in Figure 6.

5.3. VGG19 MODEL RESULTS

The VGG19 model reached saturation after ten epochs, so the training and validation of the model were completed after that. The accuracy and losses of the model during training and validation are shown in Figure 7.



Figure 6 - Accuracy and losses of the VGG16 model.



Figure 7 - Accuracy and losses of the VGG19 model.

Model training and validation are stopped at the end of the tenth epoch because model saturation occurs (accuracy and losses converge). The final values are given in Table 3.

Table 3 - Results for the accuracy and losses of the
VGG19 model in the last epoch.

Last	Training	Training	Validation	Validation
epoch	(Loss)	(Accuracy)	(Loss)	(Accuracy)
10	0.2295	0.9213	0.6191	0.8237

5.4. COMPARING MODEL RESULTS

For the final determination of the best model, the accuracy achieved during the validation of the CNN model is looked at. The ranking of the three CNN models considered in this paper is given in Table 4.

Table 4 - Ranking of selected CNN models.

CNN model	Validation (Accuracy)	Rank
ResNet50	0.7531	3
VGG16	0.8361	2
VGG19	0.8237	1

VGG16 turned out to be the best CNN model among those selected with an accuracy of 83.61%. On the second place is VGG19, which achieved a precision of 82.37%. ResNet50 proved to be the worst with an accuracy of 75.31%. Although VGG16 is the best of the selected models, its accuracy of 83.61% is far from the ideal 100%. Two important problems can significantly affect the accuracy. The first problem is related to the wrong choice of CNN model to solve a certain type of problem, errors in the configuration of parameters, and errors in the selection of metrics for evaluation. However, it is possible to use already trained CNN models with certain modifications if necessary which reduces implementation errors. The second problem is related to the database that is used because its size can have a big impact on training a CNN model.

RAF-DB database had the greatest impact on the obtained accuracy results. The class happiness represents 41.2% (5957 images) of the total number of images while the smallest class (fear) has only 355 images (2.45%). It is not possible to ignore this and expect the CNN

model to successfully make predictions for all images that should belong to the fear class. Furthermore, some image that is associated with one of the emotions (e.g. fear) can act as an error because it can be interpreted in two ways i.e. according to human perception, that image may be more appropriate for some other emotion (e.g. surprise). Also, understanding emotions based on facial images can be misinterpreted due to cultural differences between people [25]. The last factor refers to the noise in images. RAF-DB contains images that are damaged and distorted i.e. the appearance of blank (completely white or black) images or blurred images in which the face is not visible. By going through the database, these kinds of images were largely moved out. Taking all these factors into account, it is not possible to get close to 100% accuracy without using some additional tools, methods, techniques, etc. There are several successful applications of the CNN model over the RAF-DB database. At the time of writing this paper the highest accuracy result achieved is 90.35% using the EAC model [26]. It is a combination of the ResNet50 and the EAC (Erasing Attention Consistency) method. The EAC method is used to remove the negative influence of noise in the image labels [26].

6. CONCLUSION

People's opinions are divided regarding the emergence and use of artificial intelligence. Some optimists think that artificial intelligence will solve all of the problems that exist, while there are pessimists who think that this is the beginning of the end. Although one should not be at the end of one side or the other, it is necessary to look at the real possibilities of artificial intelligence to gain new knowledge, improve the daily life of mankind, overcome limitations, etc. This paper dealt with the use of CNN models for solving the problem of classification of images of human faces and their emotions. ResNet50, VGG16, and VGG19 models were used. The input data belongs to the RAF-DB dataset. Based on the concept of transfer learning and modification of the RAF-DB dataset, accuracy results were obtained. The VGG16 model stood out as the best, achieving a precision of 83.61%. On the second place was the VGG19 model with an accuracy of 82.37%, and on the third place was the ResNet50 model with 75.31%. These model accuracy results are not ideal, but there is still room for improvement. One of those improvements refers to the combined application of existing CNN models and additional tools, techniques, methods, etc. The direction

58

of future research is the application of additional tools, techniques, and methods to surpass the currently bestachieved result (EAC model). Also, some other ideas include comparing the results of other CNN models or more of those models over the same dataset. Other datasets contain images of facial expressions that can be used to solve the problem of emotion classification.

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COMPUTER SCIENCE AND ARTIFICIAL INTELLIGENCE SESSION

THE USE OF COMPUTER VISION IN PRECISION AGRICULTURE

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Abstract:

Precision agriculture is an innovative farming method that aims to maximize crop yields while minimizing waste. One of the key technologies used in precision agriculture is computer vision, which involves using cameras and sensors to collect data on crop growth and health. This data is then analyzed using machine learning algorithms to provide insights on how to optimize farming practices and improve yields. In this article, we provide an in-depth analysis of the role of computer vision in precision agriculture, with a focus on its applications in crop monitoring, the various types of cameras and sensors utilized in computer vision systems, and the diverse machine-learning algorithms employed to analyze the data collected. Through this analysis, we aim to offer a comprehensive overview of the potential of computer vision to revolutionize the way we grow and harvest crops, and the impact it could have on the future of agriculture.

Keywords:

Computer Vision, Algorithms, Technology, Machine Learning, Agriculture.

INTRODUCTION

Precision agriculture is a solution that aims to address the challenges and limitations of traditional farming methods by leveraging the power of technology. By using various sensors and tools such as drones, satellites, and computer vision, farmers can collect and analyze data to gain valuable insights into crop health, growth patterns, and environmental factors. [1] This enables them to make data-driven decisions about when and how to plant, irrigate, fertilize, and harvest their crops, resulting in improved yields, reduced waste, and lower costs. With the help of artificial intelligence and computer vision, precision agriculture can automate many of these processes, freeing up farmers to focus on more complex tasks and enabling them to maximize their productivity and profitability.

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2. IMPORTANCE OF PRECISION AGRICULTURE

Precision agriculture involves the use of advanced technologies such as sensors, GPS, GIS, IoT, drones, and more to optimize the utilization of natural resources and inputs to achieve specific crop production and quality. Through digital farming and more efficient use of resources and time, farming can become more efficient and consistent. This paper provides an overview of the fundamental elements of precision agriculture, its various components, and its future implications. [2]

Precision agriculture involves a wide range of automated measurements taken at different spatial scales, from individual plants to entire fields, and at various points in time during crop production. Initially focused on yield sensors, precision agriculture has expanded to include tools for mobile measurement, determining plant condition, and identifying possible pest infestations. Wireless communication allows for field data to be transferred to logging software. Precision agriculture technology is intelligent and can aid in environmental protection and sustainable development. Real-time crop processing and fertilizer equipment can be implemented with this technology, along with identifying and registering interventions or treatments of growth stage cultures. During harvest, the technology can help identify and measure quality parameters of the crop, depending on where it is grown in the field. Tagging different batches with all relevant information can aid in food safety and quality assurance. Overall, precision agriculture technology can be a crucial tool in improving crop production and ensuring food safety and quality. [3]

By enabling farmers to make data-driven decisions, precision agriculture reduces the need for guesswork and increases the accuracy of farming practices. This results in greater profitability for farmers, a more sustainable and safer food supply for consumers, and a reduced negative environmental impact of traditional farming methods. The integration of computer vision technologies in precision agriculture further enhances its capabilities. For instance, computer vision can help identify plant diseases and pests, monitor crop growth, and estimate yield, among others.

The use of computer vision in precision agriculture can optimize crop yields, reduce waste, and increase operational efficiency, leading to significant long-term savings and increased yields compared to conventional farming methods. [4] Overall, precision agriculture and computer vision technologies have the potential to revolutionize the farming industry and usher in a more sustainable and efficient future.

3. COMPUTER VISION METHODS IN PRECISION AGRICULTURE

Much precision agriculture work uses some type of sensor to relatively inexpensively obtain information about spatial and temporal changes in crops, soil, weeds, disease, and more. [5] Computer vision is an advanced technology with the capability to identify, locate, and track objects. It has been extensively researched and implemented in various fields, including precision agriculture and industry. Computer vision applications range from automated driving and surface defect detection to object detection and localization, automated harvesting, robotics, crop phenotyping, and crop yield estimation. Automated driving technology enables vehicles to recognize their surroundings and drive without human intervention. However, varying lighting and obstacles, make it an extreme challenge.

For example, it may be difficult to see pedestrians and lane markings accurately. Surface defect inspection technologies can identify and differentiate anomalies from desired features, making them essential in automated production. The aim is to identify and analyze errors quickly and reliably, which is a major challenge. Implementing deep learning techniques for object detection and localization can be challenging due to their high computing power and storage requirements.[6]

The growing accessibility and affordability of computer vision technology represent a significant step forward for the agriculture industry. As the climate and environmental changes continue to affect global food needs, the implementation of AI technology can transform 21st-century agriculture by:

- improving efficiency in time, labor, and resource management;
- enhancing environmental sustainability;
- optimizing resource allocation;
- providing real-time monitoring for better product health and quality.

However, the integration of this technology will require changes in the agricultural industry, and farmers' knowledge must be translated into education about artificial intelligence.

4. APPLICATION OF COMPUTER VISION IN AGRICULTURE

Computer vision allows machines to interpret and perceive visual information similar to humans. In agriculture, computer vision combined with a remote camera provides a non-contact and scalable sensor solution. Its applications in agriculture include AI-driven animal monitoring, visual quality control, automated inspections for quality maintenance, and infrastructure monitoring.

Moreover, computer vision has the potential to improve crop monitoring and yield forecasting by identifying crop health, growth patterns, and potential stressors through image analysis [7]. Computer vision technology enables robots and machines to mathematically perceive their surroundings pixel by pixel, creating algorithms and models to understand images more accurately. This technology has found extensive use across the agricultural and industrial food production sectors. This includes the implementation of sorting systems for a wide variety of crops such as oranges, papayas, almonds, potatoes, lemons, wheat, corn, and rice. [8].

Computer vision models can be trained using datasets to process images of plants, allowing for precise insight into farm activities remotely and precision agriculture is a systemic solution that balances productivity and environmental concerns by increasing economic output while reducing energy requirements and environmental impact. Figure 1 depicts the use of computer vision technology on tomatoes in disease identification, which is just one example of how computer vision can be used in fruit and vegetable production. By utilizing computer vision technology, farmers and producers can automate the grading, sorting, and quality control of fruits and vegetables.

With the help of computer vision, fruits can be classified based on their size, shape, color, texture, and other characteristics. This enables the sorting of fruits based on their quality, ensuring that only high-quality fruits reach consumers. Cameras can capture images of fruits, and computer vision algorithms can detect defects such as bruises, cracks, and discolorations, after which the system can sort the fruits according to their quality.

Yield estimation is another fruit production application of computer vision technology. Computer vision systems can analyze images of fruit trees or plants to estimate the number of fruits present, their size, and their ripeness. This information is crucial in optimizing the harvesting process, allowing growers to harvest fruits at the peak of their ripeness, which results in high-quality fruit production. In summary, the utilization of computer vision technology in fruit production aids growers in optimizing their production processes, reducing waste, and ensuring that high-quality fruits are delivered to consumers.



Figure 1 - Application of computer vision on tomatoes in disease identification [9].

4.1. COMPUTER VISION APPLICATIONS FOR CROP HEALTH MONITORING AND INSECTS AND DISEASE DETECTION

With the aid of computer vision systems, it is now possible to identify and classify crop diseases and detect physical damage caused by pests and insects. This provides farmers with prompt notifications about unfavorable field conditions, and the system can monitor the spread of diseases or infestations to alert them to any potential risks.

This eliminates the requirement for conventional, resource-intensive scouting practices that are frequently utilized in the industry, which can be both expensive and time-consuming [10]. Computer vision technology is becoming increasingly popular in the agriculture industry as a means to optimize crop yield. Machines can now be trained to detect and pick up damaged or infested crops, reducing waste and improving crop quality. Through the use of color imaging and in-depth analysis, computer vision technology can assist farmers in diagnosing issues with their crop output and taking preventative measures to address them. [11] Computer vision technology can also aid retailers and farmers in efficiently sorting their crops by ensuring that the correct fruits and vegetables are stored together.

Object detection allows a machine to scan thousands of individual objects as they pass by a sensor, discarding any low-quality crops automatically and freeing up farmers to focus on other tasks. Computer vision technology has a wide range of applications in agriculture, including planting and harvesting, weeding, and detecting plant health issues [12].

Figure 2 shows the result of observing tomato ripeness using computer vision.

The health, yield, and quality of plants are primarily affected by the presence of micro and macronutrients in the soil. Monitoring the growth stages of plants is crucial for enhancing production efficiency. It is essential to comprehend the relationship between plant growth and the environment to make necessary adjustments for improving plant health.



Figure 2 - Observing tomato ripeness using computer vision [13].

The use of unmanned aerial vehicles (UAVs) allows for the collection of aerial data to predict crop and soil conditions, which were previously determined by human observation and judgment. With the help of computer vision technology, these data can be used for intelligent crop monitoring. This data can be analyzed and interpreted using Visual Sense AI, which enables:

- Plant health monitoring;
- Accurate earnings forecasting;
- Detecting malnutrition in crops faster than humans can achieve.

AI models can alert farmers to specific problem areas so they can take immediate action. This technological advance offers a more efficient and cost-effective way of monitoring crops, potentially leading to improved yields and quality, and a more sustainable approach to agriculture.

Manual observation of tomato ripening stages is a labor-intensive process that can be supported by AI in precision agriculture. To achieve this, researchers collect images of tomatoes at different stages and under different lighting conditions. This model outperformed human observation in accurately identifying tomato ripening stages, which eliminated the need for daily field visits by farmers.

In a separate study, researchers developed an algorithm that could accurately assess the ripeness of tomatoes by analyzing the color of five distinct areas on the fruit. The algorithm achieved an impressive detection and classification rate of 99.31%. With AI, farmers can reduce the labor-intensive process of observing and assessing crop growth and maturity, which is challenging and time-consuming. AI can handle much of this work with ease and impressive precision, making precision agriculture more efficient and sustainable.

4.2. PREVENTING CROP DISORDERS WITH COMPUTER VISION

Computer vision technology has proven useful in detecting agricultural disorders, but it also has the potential to prevent them. By using unmanned aerial vehicles (UAVs) equipped with computer vision AI, farmers can automate the spraying of pesticides and fertilizers across large fields with uniform precision. The use of real-time target spraying area detection can improve the accuracy of drone sprinklers and decrease the likelihood of contamination to plants, animals, people, and water resources. Although there are challenges involved in assigning mission sequences and trajectories to individual vehicles, researchers at Virginia Tech have devised a smart misting system to address this issue.

To detect and remove weeds with precision, the smart misting system employs servo-motor-controlled sprayers and computer vision technology. By utilizing cameras mounted on the sprayers, the system can record the location of weeds and analyze their size, shape, and color. This information is then used to accurately remove weeds through the targeted application. Thanks to the accuracy of computer vision technology, the system can avoid collateral damage to plants and the environment.

In summary, computer vision technology has the potential to revolutionize agriculture by automating spraying processes and reducing the risk of contamination, thereby improving crop yields and ensuring the safety of humans, animals, and the environment. The smart spray system developed by Virginia Tech is an example of how computer vision can be used to deliver precise amounts of herbicides and prevent collateral damage to crops or the environment.

In addition to aiding farmers in identifying and addressing issues with their crops during the growing season, AI computer vision can also assist with postharvest processes. Computer vision algorithms have the potential to automate the grading and sorting process of harvested produce by analyzing its size, shape, color, and volume. This technology offers superior accuracy and efficiency compared to human inspectors. By using computer vision technology to inspect harvested crops, farmers and distributors can ensure that only the best quality produce is selected for sale, reducing waste and improving profitability.

This process can also be performed at a much faster pace than manual sorting, allowing for more timely delivery of fresh produce to markets and reducing the risk of spoilage. In summary, computer vision technology offers numerous benefits for the agricultural industry, from crop health monitoring to post-harvest processing. With the continuous advancement and widespread adoption of this technology, it is expected to play a progressively significant role in enabling farmers to optimize their crop yields, reduce waste, and enhance profitability.

5. CONCLUSION

From the studies mentioned above, we can conclude that computer vision technology is being increasingly adopted in agriculture as a rapidly developing technology. It is expected that in the future, computer vision technology that relies on large data sets will be widely used in all areas of agricultural production and will be leveraged to address various agricultural challenges. The integration of computer vision technology and artificial intelligence algorithms will enhance the economic, overall, coordination, and automation system performance of agriculture.

In conclusion, precision agriculture is a relatively new approach to agriculture that utilizes modern technologies and techniques, including computer vision, to provide a detailed and comprehensive view of farming practices. Computer vision enables the identification, localization, and tracking of objects and has been applied in numerous fields, including industrial and precision agriculture.

It has the potential to enhance crop monitoring and yield prediction by using image analysis to detect plant health, growth patterns, and potential stress factors.

By optimizing soil use, precision farming helps maintain soil quality and ensures a stable food supply, making it an essential tool in addressing global hunger challenges.

While precision agriculture technologies may appear costly initially, they result in significant long-term savings compared to traditional farming methods, ultimately increasing production. Overall, the use of computer vision in precision agriculture highlights its potential to change the way we grow and harvest crops, and improve the efficiency and sustainability of agriculture.

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SINTEZA 2023 INTERNATIONAL SCIENTIFIC CONFERENCE ON INFORMATION TECHNOLOGY, COMPUTER SCIENCE, AND DATA SCIENCE

INFORMATION TECHNOLOGY SESSION INVITED PAPER

MEASURING INFORMATION APPLICATION FOR ACTIVITY IN SYSTEMS SUCCESS

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Abstract:

This article discusses the problem of measuring information quality through the lenses of Solow's "information paradox" in economic theory, drawing insights from fields such as system science, cybernetics, complexity science, and action theory. The author's research focuses on the pragmatic facet of information quality, which examines the success of information application in human activity. The article argues that mathematical models of multi-level changes in varying conditions must be created to study the pragmatic aspects of information quality. The aim is to develop a formal representation and predictive explanation of information applications, which could lead to accurate predictions of the impact of information applications based on mathematical models. The complex nature of multi-level changes and cause-and-effect relationships in information-driven systems makes building these models challenging. The article highlights several interrelated research directions in this area.

Keywords:

Information, Cybernetics, Models, Solow paradox, Quality.

INTRODUCTION

In 1987 Nobel Prize laureate Robert Solow [1] described his information technology paradox: "We can see the computer age everywhere but in the productivity statistics". Despite various facets of the paradox being explained – at least partially, many times over, for example in [2] – [6] soon half a century passed, but this paradox tends to reincarnate oneself in one form or another. For example, in 2023 new report was published [3] about the very same paradox formulated for artificial intelligence applications by businesses. Still, modern research does not show clear growth in productivity due to information technology use. For example, recent Goldman Sachs research shows paradox still can be found as Paradox 2.0. I am trying to discuss this paradox from a wider view.

First, from a multidisciplinary view, it is not just a productivity or even economy theory problem, but a wider problem of information application peculiarities in the human activity of various kinds and quality obtained, due to information application, and practical results. Second, as a more general viewpoint of activity theory and information application by humans in activity. Third, as a problem of Cybernetics, System sciences and Complexity science.

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It may come as a surprise that these issues were not yet studied enough. Information application is at the cornerstone of activity theory [7], cybernetics, systemics, and complexity science [8], [9]. Still, we can plan space missions predictively, we can design and build rockets to fly to other planets at certain times, to certain points in the universe, predictively, with very high accuracy, based on the laws of ballistic and thermodynamics. We may know almost for certain where spacecraft will be in years, at which point, and why - based on cybernetics and system science, among other sciences. But compare this with what we can do when predicting information application. Generally, we can measure entropy and some other characteristics of information but cannot predict which results will be obtained with the information used. Such a situation looks extremely strange, considering the role of information application in human society. Our appearance as a species is to a large extent the result of our ability to process information, to communicate in our actions with other humans and later, to socialize activity. But we cannot yet predict the results of information application. As Russian poet Fedor Tutchev wrote, "We cannot know further ways of our word - how it'll be drifted." And there are scores of examples in history when "our word" changed almost everything, and it is always the word that precedes all changes made by humans. This system-theoretic, cybernetic, and action-theoretic statement is directly reflected in the first part of the first statement of the Old Testament: "In the beginning was the Word, and the Word was with God, and the Word was God" (John, 1:1). Still, we are unable to measure and predict what, how and when our own words will change us and the world around us. Looks very different from the spacecraft case. Further, the creation of the first societies and multiple civilizations has a direct cause in progress using information. Some stunning facts about this were the first known cases of information used by the first person in history whose name is known nowadays: Kushim from Mesopotamia, more than 5 000 years ago. He used information for bookkeeping and human activity. And signed it. Another known case from the same time. Beer recipe. From similar old times. Still actually used by us nowadays. Finally, if you will look at what is left after us, you will find out that the most valued artifacts from history are information artifacts. It is religious texts, myths, writings, and books. Photos and letters. Records. It is not material things civilizations used to produce or consume, but informational artifacts. Still, we have made a little effort to understand how that information is used, and what results we may predict.

But – we are experiencing a clear "digital revolution" – still being unable, to a large extent, to predict its results. Like, for example, many modern creators of artificial intelligence (AI) openly discuss that they are being unable to predict the results of the latest AI incarnations use due to possible harm to human activity. Again, looks very different from rocket science results.

2. STATE OF THE RESEARCH

Concerning the state of the research in the fields, related to information use, it is urgent to notice relations of activity, causation, and information use in a broader sense. "Causation can be understood as the transfer of information, if information is understood in the proper way as a physical mode" [10]. Further, "Causation can be represented as a computational process dynamically embodied in matter or whatever other "stuff" is involved, in which at least some initial information is retained in each stage of the process" and "The most dominant current view of cognition is the syntactic computational view".

Thus, to describe information use, it can be considered a kind of use causation in nature - by humans. This use occurs due to humans' ability to act in nature based on cognition and consciousness and the use of causation. Action can be naturally represented by computation. These considerations provide hope for creating formal means of activity computational modeling regarding information use for causation in action. Such formal means can be based on the quantification and computation of forms. These formalisms should have a predictive nature and be able to explain possible future causal relations and their characteristics. I believe that they could be created using metamodels (representing meta-forms) and programming languages to support computational predictive formal modeling. As of now, for reasoning about information use various frameworks of best practices applied. Such frameworks are rarely based on formal, predictive models [11]. Formalizing this knowledge and building computational models based on "best practices" as well as on the data, collected during human actions may allow a significant rise capability of the system due to IT use. As stated in [12] "When an event $e_{\iota} \in E$ occurs, we may say that it is associated with some kind of information. In a system (multirobot system considered), events may be classified along three classes, depending on the type of conveyed information: (1) internal events, concerning the robot's activities and information gathered internally by the robot (e.g. end of an internal processing task, reaching some

position, etc.); (2) external events, concerning changes on the mission execution environment and information obtained through the robot's sensors (e.g. detection of an obstacle, finding an object relevant to the mission execution, observing the movements of another robot in the team, etc.); and (3) received messages, concerning the information provided by other team members (e.g. detection of an environmental condition, individual state information, a negotiation bid, synchronization-related information, etc.)." Then, relative performance variation $\frac{\Delta p_k}{p_k}$ and relative mission $\cot \frac{\Delta i c_k}{c_k}$ estimated considering event o_k occurrence, Then, information utility associated with the event occurrence o_k is measured by the dimensionless ratio u_k of the values mentioned.

Next, state transition graphs are used to account for information values. It is worth noticing, that the author uses similar ideas, but based on measure-theoretic and probability theory, to suggest measures of system potential.

Automatic abstraction [13], [14] in scientific research can be used to build models of possible states, transitions, and cause-and-effect relationships depending on the information obtained. In [14] a new computational model of multiple abstractions of knowledge is proposed. This model is called Multi-AH (Abstract Hierarchical)graph and is an extension of work on mobile robot navigation. It allowed for representing different types of relations between concepts, and virtually any kind of information, both in the form of concepts and relations and in the form of annotations attached to those concepts and relations.

Building models of activity regarding information use can be considered as a subdomain of Higher Order Mining [37], which encompasses methods for the discovery of knowledge by processing models (instead of data), such as meta-learning, model adaptation, model comparison, temporal mining, mining models (i.e., clustering of association rules) and Change Mining - the discovery of changes in evolving models. In [15] stated that "the need to store, maintain, query and update models derived from the data has been recognized and advocated. However, these are only two aspects of the dynamic world that must be analyzed with data mining: The world is changing and so do the accumulating data and, ultimately, the models derived from them. The challenge does not only lay in adapting the models to the changing world but also to analyze how the models change and when they do so". The authors of [15] proposed a new paradigm for data mining in the evolving world.

Change models, as well as data models, can require higher-order models. The same applies to information and knowledge models. However, the role of higher order models in data, information, and knowledge use, in building and application of data, information, and knowledge is not yet described enough. The reason for this is, in my opinion, lower-level models of data, information, and knowledge use are not yet developed to the needed extent. This, in turn, is based on the absence of a solid concept of information applications in general and the role of high-order models in this - in particular. I am suggesting an explanation of data, information, and knowledge use as a hierarchical process of various aspects of activity model creation and further use of models created for action problem-solving purposes. This includes complex, higher order, predictive, dynamical models of activity construction and use, including such aspects of activity, which are related to answering complex questions about activity. According to such an explanation, activity models are complex in various ways or directions. First, activity always consists of some interrelated parts, at least - subject and object, as well as means of action and possibly other parts and relations between them. This direction is traditionally described by various combinations of parts possible (by varieties and holarchies) - in activity theory. Second, the direction related to predictions of the possible future outcomes depends on decisions made and actions fulfilled. Third, reflections of objects and relations are mentioned of various kinds and various levels in some reflection hierarchies. Such reflections are used to solve problems, raised before humans when we perform our activity. If to represent various directions as orthogonal coordinates, moving along coordinates can be explained as solving a system problem with the use of information of various kinds and various hierarchies in reflection order. An example can be seen in Figure 1.

In terms of the axis, by holarchy axis V, moving to a higher variety (less holarchy) will mean considering more parts of activity (including subject, object, and means parts) and more relations between them, which is common in various models of activity theory. By possible future outcomes (possible effects, P) of actions axis, moving by axis will mean better results of actions fitness to demands, according to goal, i.e. better results. By reflection axis R, moving to higher order reflection hierarchy would mean a kind of abstraction and back – kind of concretization.



Figure 1 – Illustration of human activity problems solving with the use of various kinds of reflections in the space defined by V, P, R axis.

Thus, to represent the decision of human action problem, we may represent the initial problem formulation as a vector (or possible vectors) on the plane defined by variety V and possible effects P axis. Vector represents desirable types of outcomes by starting state and finish state. The decision of the problem could be represented as moving up by reflection axis R - by abstraction or other types of reflection - or example, till an abstract decision can be generated, and then - moving back to concretize and implement abstract decision obtained in practice. Such a way of the decision is the reminiscence of many systems theoretic and cybernetics methods to decide complex practical problems, with emphasis on information processing. Generally, such a trajectory in space of given coordinates would represent obtaining results of information used for solving practical (related to action, to human practice) problems. The next step in the research is to model and measure such trajectory and so - information use, based on formal mathematical models, predictively and quantitatively, because, as said by many researchers, "You can't manage what you don't measure". The quality of using information, information value, and business value of information has attracted researchers for decades. H. Tohonen, M. Kauppinen, and T. Manisto [16] conclude that the evaluation of IT business value is challenging and has been on both research and practitioner agendas for more than two decades but remains a challenge. One reason for this is that such measures must, among other facets, represent the quality of purposeful changes in activity caused by obtained information, particularly in changing conditions. This facet is closely related to the concept of information pragmatics. As stated by J. Talburt [17]: "That concept is the intent of the message-that is, to what use will the receiver put the information, and more importantly, will the information have value (utility) for the receiver in the context of its intended use? These three concepts of information format, meaning, and purpose form the foundation of information quality and allow it to be anchored in measurable terms. The same three concepts also underpin the study of signs and symbols known as semiotics, where they are called syntactic, semantics, and pragmatics." J. Talburt [17] formulated the main principles of information quality. The need for IQ measures includes measurements of the quality of deliberate potential changes in actions due to information obtained, as well as the fitness of the results to changing demands. Predictive mathematical models for such measures, based on mathematical formalism, have not been developed yet. This is particularly the case for predictive mathematical modeling of the use of information for actions and the success of systems in changing conditions. This approach requires a description of the characteristics of the use of information for actions and measures of the success of such actions in changing conditions.

This approach can be seen as an extension of the Batini [18] and Scannapieco approach to evaluating the quality of information: we aim to investigate the relationship between the quality of information and the quality of the processes output (or, simply, the process quality) that make use of information to be produced. Since processes are made of decisions and actions, we aim in turn to relate information quality with the quality of actions and decisions that make use of information.... We want to deepen our understanding of how the information processor, be it a human being or an automated process, can manage the fitness for use of the information consumed" [18], [19]. This approach is based on the concept, described by Y. Lee, R. Wang, and D. Strong as: "the concept of "fitness for use" is now widely adopted in the quality literature" [19].

A review of the approaches for estimating the value of information, with a focus on fundamental and mathematical methods, was provided in [16] and by most other researchers using an empirical approach. As it is noticed by Y. Lee, R. Wang, and D. Strong about this approach: "The disadvantage is that the correctness or completeness of the results cannot be proven via fundamental principles" The fitness for use is investigated by [19]. As noticed by L. Floridi and P. Illari: "Qualitative descriptions of the meanings of words or phrases such as 'information quality', or 'timeliness' are not the same as formal metrics required to measure them, and which are needed for implementation" [20]. The approach suggested in the article is based on a fundamental, predictive mathematical modeling approach to compute formal IQ measures based on the theory of system potential results already obtained. The approach further elaborates on concepts and models suggested in [21].

New measures, suggested by authors, are based on probabilistic and entropy measures, which are calculated with mathematical models of information use and its use success levels. Such measures and formal models may allow solving various problems of information use, and digital transformation as mathematical problems, such as operation research and mathematical programming problems. Such an approach is like the approach to information processes modeling, suggested by C. Batini and M. Scannapieco in [22]. However, the approach has some deficiencies, as mentioned by its authors: "It does not distinguish between or provide specific formalisms for operational processes, which make use of elementary data, and decision processes, which use aggregated data" [18]. The reason for such a situation is defined by the nature of information processing. Such processing inevitably leads to the purposeful change of human action and the exchange with the environment [23]. But the mathematical models of such changes in human action are not yet available in the needed details. The situation could be improved with the use of various approaches available to describe the changeable activity, like the theory of functional systems [24] - if it is operationalized with appropriate mathematical means.

3. PROPOSED DIRECTIONS OF THE RESEARCH

Below are suggested hypotheses and formalisms to explain and formalize various research results related to the wider explanation of the "Solow paradox".

Robert Solow: "We can see the computer age 1. everywhere but in the productivity statistics". Possible system science, cybernetics, complexity science, and action theory explanation: The economy does not produce more output with the same number of inputs because of IT use. Information technology does not change physical laws but changes possibilities to act, to innovate, helps to explain possible future results of actions and to change decisions and intentions (knowledge work made, information states produced). It is needed to research possible changes caused by information due to further realized cause-and-effect relations, not just relations of inputs and outputs. Various authors tried to explain the Solow paradox. Let us try to classify their main explanations, simultaneously suggesting system theoretic, cybernetic, and action theory versions of such explanations. Selected are three classes of explanations: prominent researcher of IT value problem, Eric Brynjolfsson explanations, further authors explanations, and modern explanations.

2. First "wave" explanations (Eric Brynjolfsson, Paul Strassman, John Thorp from Fujitsu consulting group [4], [25], [26]): 2.1. Uneven and concentrated distribution of the labor productivity gains. Possible system science, cybernetics, complexity science, and action theory explanation: Physical ("material") results (effects) enhancements can be obtained sporadically and unevenly because (2.1.1) cause-and-effect relations changes do not necessarily happen once information obtained (input/output relation may be unchanged or minor changes happened immediately, some other requirements have to be satisfied, some additional actions and events required in some systems, by some people), and (2.1.2) Information may change action entirely, including its goal and requirements to inputs and outputs, thus efficiencies of old and new ones cannot be compared, because results of an action before changes applied and after changes applied not comparable. For example, (2.1.1) for the ratio of input and output to be enhanced, some other additional actions shall lead to some needed events to enhance efficiency, and (2.1.2) enhanced action may lead to action or its results (product or service) of better quality, or result, which satisfy other need, solve another task.

2.2. Implementation lags. Possible system science, cybernetics, complexity science explanation: (2.2.1) Time is required to realize cause-effect relations once information changes. (2.2.2) To modernize, innovate, to progress chains of requirements can be needed to be satisfied, this may take various resources, complex efforts, and some time.

2.3. Mismeasurement. Possible system science, cybernetics, complexity science explanation: (2.3.1) Not only input/output measures characterize actions change. Input and output quantity and quality (separately or together) as well as their changes of various kinds shall be considered too. (2.3.2) Other facets of actions and their results as well as changes may be required to measure, not just inputs and outputs.

3. OTHER PROMINENT AUTHORS' EXPLANATIONS.

3.1. Free products and services created due to modern information technologies, which cannot be measured in terms of economic efficiency. Possible system science, cybernetics, complexity science explanation: Modern IT may lead to various free products and services creation because of business models innovation, including the use of non-financial results, in some cases with hopes for future or indirect monetization [27]. They cannot be easily compared with traditional products and services due to differences in business models, among other differences in related activities.

3.2. New products and services or higher quality products and services created due to modern information technologies. Possible system science, cybernetics, complexity science explanation: Modern IT may lead to various products and services creation or radical changes in their quality. Many of them are incomparable with traditional products and services, the result of innovation and creative thinking, and cannot be easily measured concerning traditional products and services. For example, so-called "uberization" results are hard to compare to traditional businesses.

NEWEST EXPLANATIONS OF MODERN DIGITAL TECHNOLOGIES PARADOXES [3] – [28].

4.1. Competition mechanisms. Businesses, which do not use modern IT properly, tend to disappear. Possible system science, cybernetics, action theory, complexity science explanation: IT use allows new, innovative, creative

reactions to market changes, environmental changes, and on appropriate changes in the competition. Such reactions must incur information processing before they are realized. Competition is exceptionally dynamic. This system's dynamics shall be measured predictively, with mathematical models. Competition helps to create new, innovative products and services, and it is one of the facets of using information.

4.2. Price increase due to higher quality. Products and services of different qualities cannot be compared by the relation of their input to output. Possible system science, cybernetics, complexity science explanation: A product or service with better quality shall be considered a new product. The new product may solve other tasks, have other functions, have other stakeholders, and other requirements. For example, traditional wire phones cannot be compared with modern smartphones. Traditional ones can be 1000 times cheaper and consume 1000 times less energy. But it cannot perform all the 1000 tasks which modern smartphones can. We shall compare products and services by all possible functions, goals, and requirements they can fulfill - in various, changed conditions. Such a measure is not a measure of economic efficiency, but a more complex measure. For example, dynamic capability measures or the measure of the system potential regarding information use can be used [29] – [31].

4.3. Monopolistic behavior. No comparison may exist for the products and services of monopolists. Possible system science, cybernetics, complexity science, and activity theory explanation:

Disregarding market position, business use of information brings results. The measure of that results correspondence to changing market and environmental conditions can be measured. This measure of correspondence can be enhanced concerning the measure before enhancement is made. Conceptional explanations provided should lead to further research which could lead to the creation of modern theory, with the potential to formally explain the formation of information use, thus able to predict the results of information use on mathematical models. Such formalisms, if created, could be used as part of system science, cybernetics, complexity science, and activity theory to build models of information use and methods to predict such use results.

5. CONCLUSION

The problem of information use and its quality research are discussed. The pragmatic facet of information quality is considered based on the system theoretic and cybernetic paradigm of information use. As a result, the facet of information quality is determined by information used for actions in the systems discussed. It is shown that information is used in practice to change, enhance, to ensure systems actions' success. The main features of the problem of information use and its quality research from a pragmatic viewpoint are discussed. To solve the problem, mathematical models of multi-level changes due to possible multi-level reflections obtained in possible changing conditions should be built. As well, appropriate measures of system success due to the specified multi-level reflections use shall be suggested. Such measures could be based, for example, on information use success assessment with mathematical predictive modeling of human activity results in fitness to the demands. They should allow deciding problems, devoted to possible purposeful alternating of systems and their functioning, due to information of various kinds use.

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74

SINTEZA 2023

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INFORMATION TECHNOLOGY SESSION

BAB (BUSINESS APPLICATION BUILDER) FRAMEWORK FOR RAPID DEVELOPMENT OF BUSINESS INFORMATION SYSTEMS

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Abstract:

This paper presents the BAB (Business Application Builder), a software framework for the rapid development of business information systems prone to frequent changes in business conditions and/or user requirements. The proposed framework is a programming pattern for a business information system in which a business information system is modeled as a set of related design patterns that implement common features of a class of business information systems. An object-oriented approach and a design pattern concept were used to model the framework, while the implementation is done using (but not limited to) selected technologies. The proposed solution is evaluated through the example of a business information system of medium complexity.

Keywords:

Business Information System, Meta-Model, Software Development, Rapid Application Development.

INTRODUCTION

Modern society has faced increased global interconnectedness facilitated by technological advancements for decades [1], [2]. To optimize business processes, automate tasks, and facilitate the work of employees, the information systems supporting the business logic and workflow of organizations have become increasingly complex. Modern information systems are required to enable users to work from spatially and globally distributed locations, use diverse devices [3], and interact with components (data, computer programs) that are logically and spatially distributed and, most often, largely heterogeneous [4]. Additional aspects that are especially important for the subject of this paper are two mutually opposed goals to be met: rapidly changing user requirements (both functional and non-functional) [5], and the severe requirement for continuous software integration and delivery [6]. This all means that, from a developer's point of view, a capacity for rapid development, easy maintenance, and a quick upgrade of software is of crucial importance. As an attempt to respond to these requirements, in this paper, we propose the BAB (Business Application Builder) Framework. The paper is composed of six sections.

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Following this introduction, the second section presents the abstraction process and abstract component model of the BAB framework. The third section describes the BAB framework architecture, while the fourth one explains how to use the BAB framework and evaluates it through the building of a complex pattern of a business information system. The fifth section describes the implementation of the BAB framework. Section six brings the conclusion, containing the review of the results, the framework's constraints, and plans for further work.

2. ABSTRACT COMPONENT MODEL OF THE BAB FRAMEWORK

Starting from an abstract definition of an information system based on literary sources [4], [7], [8], [9]] and applying methods of analysis and synthesis to selected classes of business information systems, the characteristics of business information systems are distinguished, which are then mapped to the requirements that should be met by the BAB framework.

For our purposes, we use a slightly modified definition of an information system proposed in [7]: An information system is a system in which people and/or machines perform work (processes and activities) using information and information technology to produce information products and/or services for internal or external users. Starting from this definition, we can view an information system as a set of coordinated components that together enable the collection, processing, production, and distribution of information.

The following approach is used for the abstraction of the business information system underlying the BAB framework.

- 1. Literature sources describing functional and non-functional characteristics of the class of ERP information systems [10] are analyzed as this class of information systems best fits the application domain of BAB.
- 2. The specific business information system in operation is declared a reference information system and analyzed to collect knowledge about specific functional and non-functional characteristics and implementation technologies.
- 3. Additional information is collected from users of the reference information system through informal interviews and daily communications to gather additional knowledge about their habits and preferences.

Based on the first two steps of the used approach, a conclusion was drawn that, from the aspect of the business architecture of the specific information system, the appropriate basis for an abstract model would be a variant of the ERP system adapted to the specifics of the company's operations, i.e., that the BAB framework should enable the accelerated development of a customized ERP system in which some standard ERP functionalities are emphasized, while some of them are reduced or even eliminated. A component-based [11] and software pattern-based [12] approach to software development was chosen to enable easy reuse of the logic that is encapsulated in components and the description of a system functioning through orchestration. Based on the aforementioned conclusions, an abstract component model of the BAB framework was created, the description of which follows.

The components and their relations are maintained through the component called View which is the highest level of abstraction in BAB. A lower level of abstraction is the component used to tabulate and manipulate any descendants of the abstract ancestor. It also defines the conceptual deletion functionality with the condition that the object is free and additional conditions that can be defined as needed. As users are used to tabular display and manipulation of data through windows, the decision was made to implement the user interface through these components. In doing so, the basic operations are input, modification, and deletion of data, conditional transformation of data, and creation of "many-to-many" links. There are three more aspects of object manipulation, input/modification, and data transformation; this includes report generation as the most common use case. Therefore, we need three components for their realization. Firstly, we have defined placeholders for the insertion of additional logic at all functionally important points such as saving data before and after events. For the sake of handling sensitive data and security, operator roles are defined. Each abstract page defines a set of roles that a user must possess to be considered an administrator. Accordingly, the component will adjust and show/hide parts of the interface. In the main component that represents the application shell, a set of pages that the user can access is assigned to roles. The intersection of these two sets provides a conceptual solution to the problem of access rights for users from different sectors using the same data, which is the case with shared facilities. For example, the facility vehicle is important to users from the maintenance sector, the sales and support sector, and management.

Once we have defined the operators, we can create a component that will be bound to the user session and will take care of the identity and specific settings for each user individually, such as theme color, sounds, a predefined printer, important dates, etc. To enable synchronization of data between multiple sessions of a single user and between sessions of all users, eventhandling components using the Observer pattern were deployed [13]. We have two components, one for userrelated events and another for system events. We get the concrete event type by expanding the abstract event, which will be processed by type and additional information. We do concrete processing in the shell. Working with e-mail and printing is separated into detached components that can be included as needed. The table component includes a component with segments to run all additional functionality and optionally display additional information. To avoid formatting data individually for each column in the table, based on the data type, the table itself chooses the format. By using the same principle, we can generate a row in the header with fields for filtering data. The field type is directly determined by the data type. The table is joined by a data structure that stores the entered filtering and sorting parameters, which represents the interface between the user interface and the business logic. The initial layouts of the columns and their names are defined for each table and these names must match the description in the middle layer that supplies data from the database. An abstract type data collection and a condition description structure are all we need to connect these two layers. Based on this data, we can "on the fly" form queries to the database. An essential component for a system operation is also a component that will independently activate some processes under certain conditions. They are mostly timely conditioned.

Some of the examples of functions that are activated at a certain time, with the desired frequency of repetition, are sending an email notification of an employee's absence, updating, creating, and sending a report on the employment of employees, creating orders for minimum quantities for stock replenishment, etc.

3. BAB FRAMEWORK ARCHITECTURE

The BAB framework itself is, in essence, a business information system design pattern. It was created using an object-oriented approach and object-oriented design patterns for modeling the structure and behavior (Singleton, Builder, Template, Observer, Dependency Injection, Facade), and a functional programming approach used solely for the business logic. The basic structure of the BAB framework follows the EJB architecture [[14], [15], [16], [17]] shown in Figure 1 consists of three standard layers (presentation, business layer, and data management) where the presentation layer consists of two layers (client layer and web layer), which makes a total of 5 layers:

- 1. Database Layer (Database Layer) the concrete database in which we store data.
- 2. Persistence Layer JPA (Java Persistence API) annotated classes that describe the database structure and the JPA reference implementation of Hibernate. Business Logic Layer - Stateless EJB (Enterprise Java Bean) beans.
- Web Layer (Web Layer) A web container that houses servlets and the server part of the Vaadin Flow framework [18].
- Client Layer (Client Layer) Browser that contains Vaadin Flow, the client part of the Vaadin framework [19] and web components.



Figure 1 - EJB architecture.

3.1. PERSISTENCE LAYER

All objects of the process persistence layer are treated as objects with a common ancestor that determines their primary identity in the system. This ancestor object allows solving the following tasks: comparing two objects, forming sets of objects for presentation purposes, ensuring the uniqueness of objects in collections, sorting objects, and locking during concurrent modification of the object. All other common features and functionalities are formulated through interfaces. In this way, multiple inheritance is avoided, which simplifies the description of business logic without the burden that additional types would introduce in the utilization of the functional approach. As we work with SQL databases, the basic functionality to be implemented is to mark each row in the database with an artificial key that can be used later to sort the data; newer data will have a higher key value. The data type for the key, field ID, is Long, auto-increment, or identity, as MSSQL calls it. It allows for quick search and comparison, and prevents a user from causing an error because the database system itself takes care of the values. One can use it to calculate the hash value of objects, which is very important because all relations "to more" are realized with the help of the HashSet structure, which depends on the hash value. Another piece of data that each row must contain is the Version field, which is used for optimistic row locking necessary to support multi-user work. The implementation of the equals method, which is used to compare two objects, can already be implemented here (two objects are considered the same only if they are of the same type and have the same ID). These functionalities are described in the AbstractEntity abstract class. The equals and hashCode methods are essential for establishing relationships between objects and represent the basis of the entire framework. Specific cases that may occur in individual classes are described using interfaces. The selection of functionalities described by the interfaces derives from the most common use cases. It is expected that we will have a class of objects that will be bound to sessions and represent subjects that interact with the system. These objects must have fields for username, e-mail, and password. Many objects are described with a name that should be unique, or with numerical data. The same is true for natural keys, such as a serial number. With more sensitive objects, it is important to know when they were made and who preserved them. Much additional information can be introduced here like the arrival date and receiver of the original for the paper documents, approval and log of the changes made for financial documents, etc. A large part of the data we enter in the system will not be allowed to be deleted due to the referential integrity of the database and should be able to be marked as inactive. If a more complex pattern needs to be derived, it can be done by inheriting the AbstractEntity class. An example is the Item class. All items should have information about the manufacturer, an item from the corresponding codebook, the location where they are temporarily in the warehouse, a link to the items in the incoming and outgoing invoices, etc.

3.2. BUSINESS LOGIC

All business logic will be encapsulated in EJB objects that are stateless by nature. To use AbstractEntity, all the common functions that we can work with will be defined in the AbstractHome class. These include methods for storing, retrieving, modifying, deleting, and filtering objects. Specific functionalities will be implemented in concrete classes and defined in interfaces. An example is a class that manages users and requires an additional functionality to check the correctness of the entered logging data. The means to represent the conditions set by the user when filtering will be described in the next chapter, in the QueryMetaData class. For business logic, we force the functional programming paradigm to the greatest extent possible. The data is read from the database, then further transformed, and forwarded using the Stream API. Complex functionalities should be realized by composing functions that are considered atomic from the point of view of business logic.

3.3. WEB CONTAINER

The user interface (UI) configuration will be defined on this layer. Business systems rely heavily on a tabular display of data followed by windows for entering, modifying, and displaying details. Based on this, we can define a GenericTable that will contain rules for printing and formatting data based on a data type. One should be able to automatically generate filtering fields for each column. All this data is temporarily stored in the QueryMetaData data structure, based on which SQL queries are generated on the fly. For each column, it is necessary to define the name of the attribute in the JPA class, the name in the table, and the name in the DTO (Data Transfer Object) object that will serve the exchange of the data between the business layer and the Web layer. DTO is convenient because it allows us to perform additional transformations and ignore the relationships between objects and represent them using one or more attributes that carry user-relevant information. So, if we have a DTO for a city, we can replace the connection with the state with an ordinary String field in which we will write only the name of the state. The initial layout and visibility of the columns should be defined in the annotation and the changes made by the user will be stored in the database. It is common to have a view table accompanied by input and edit windows that we can represent with a single two-state object because the set of edit fields is almost always a subset of the set of input fields. The field type depends on the attribute type in the entity class. An important part is the validation of the entered data. We can create validators for each specific use case and just bind them to the component. A typical example is a name validator that checks the uniqueness of the entered string. To make it universal, we will represent the object we are checking and the service with corresponding interfaces. In this generic window, one can also define some processes that need to be automated, such as recording the entry date and logged-in user, when the created object implements the interface that defines this functionality. Another example is setting focus on the first input field from the top. A generic table and a generic window can be grouped under the GenericView class, which represents a typical web page. Below the table will be a section for additional information such as the number of items in the table, and a section for input, edit, and delete buttons, and additional multi-purpose buttons. What follows is about resolving privileges and deleting an item from the table. Deletion should be possible if the user has the appropriate privileges and if the object has no relation to other objects of the multi-type. We can solve this by reflection. Additional conditions that need to be fulfilled in some cases or branching effects can be defined by redefining empty methods, hook methods, which are called before and after essential operations. Another type of input window we need is for manipulating many-to-many links. We will implement them through two tables. One will represent a set of all possible, free objects, and the other the assembly of the elect. The standard functions we will have represent the transfer of one/all objects between these tables with the possibility of defining validation steps and additional functionalities. The third type is windows for data manipulation and transformation where one can describe, for example, the generation of reports, the loading of XML files, and their processing. What is still needed is to define actions in detail for each row of the table. It can be a simple dialog, an object whose class inherits one of the two types of generic windows, a button to jump to a related table where filtering should be done immediately or a component that displays textual details if the text is longer and it does not make sense to display it in a table in completely. All those functionalities are implemented through the annotations that the corresponding view will contain. For the application to work like classic applications, it is necessary to refresh the tables for all users who view the same table on which someone made a change. This will be done by using the Observer pattern [13] with the help of the appropriate event type.

4. EVALUATION OF THE BAB FRAMEWORK

We need a pre-arranged set of classes that inherit from the frame classes to build each view. We need a class for mapping data to a base table that inherits the AbstractEntity class, denoted further on by the generic type T. Based on it and the data we want to display to the end user, we need to define a DTO object that will inherit the AbstractDTO class denoted by type D, which depends on T. Next is the class (generic type V) that will encapsulate the business logic and manipulation of objects in the database. This class inherits AbstractHome, which depends on T and D. The class of the concrete view inherits GenericView and depends on T, V, D and K which represents type of end user. In the same way, we define the class which defines the entry/modification window also dependent on T, V, D and K.

In the example of an information system that was built with the help of the BAB framework, one task is to define items. By item, we mean any material good or service that a company can buy, store, and/or sell. Accordingly, the basic requirements were that it should be possible for any item to enter and/or leave the company through the appropriate type of document. Therefore, the codebook for items should be defined, and the connection of the item with the organizational unit of the warehouse where it is physically located. The additional requirement arose from the structure of the legacy application as it was at the time since there were tables representing the items that needed to be brought under the new structure. The natural solution was to generate a new abstract class structure that is lower than AbstractEntity, yet higher than any individual item class. In this way, we can check the record structure at the level of restrictions that are written in the model classes, as has been done so far; we will still have one class

to one table mapping as described by the "merged table" strategy. Another option would be to use a "single table" strategy. These strategies are standardized by the JPA specification (Team, 2020). We make the form from two model classes, Artikal (Eng. Item) and ArtikalInfo, an abstract item, and the corresponding codebook. Next, we have their projections, where we will change the lower limit of the generic from AbstractEntity to Artikal or ArtikalInfo. According to the existing form, as before, we define the service for code books and items, also lowering the level of abstraction. We also define the view for code books as before with the same changes. A big extension of the form comes with the view, which will be the basis for all items. Instead of the previous four types, T, V, D and K, we will have 8 types: ArtikliView<T extends Artikal, V extends AbstractArtikalHome<T, D>, D extends

AbstractArtikliDTO<T>, X extends ArtikalInfo, Y extends AbstractArtikalInfoHome<X, Z>, Z extends AbstractArtikalInfoiDTO<X>, E extends Enum<?>, K extends AbstractEntity & Operater-EntityInterface> extends GenericView<T, V, D, K>. As one can see, for each item, three additional types related to the codebook plus one that will be related to the item type should be defined. In this way, we can implement common functionality and checks in one place. Because of this, one can even define the design of the window for input/modification of items once and subsequently add specific fields in specific classes. The graphic representation of the extended pattern is given in Figure 2.

Using the extended pattern, we can derive a set of classes for the Vozilo entity entry as shown in Figure 3.



Figure 2 - Example - Arikal Entity.



Figure 3 - Class diagram for the Vozilo entity.

5. SOFTWARE ARCHITECTURE OF THE BAB FRAMEWORK

The implementation technologies of the BAB framework were chosen so that the application meets the following requirements: internet capability with support for various terminal devices, portability, robustness and stability, easier development, and economy in production. The requirement of internet capabilities imposed the decision to implement a web application, and the requirement of the economy in production dictated the choice of open-source technologies. The programming language Java and the JAKARTA EE set of specifications for the development of business applications in Java [17], was used as the basic language. The reasons for this choice are stability and widespread, speed, available libraries, and portability. The relational database (here the MSSQL database) and JPA specification were chosen for persistence implementation due to the dominance of relational databases and the advantages JPA has over other persistence mechanisms. For the sake of easier development and "smoother" integration of layers, the Vaadin platform ([18], [19]) is used for the front end. Figure 4 [19] shows the generic framework for using web components in the Java environment.

This enables the description of the structure and functionality of web pages (HTML, CSS, JavaScript) in the Java programming language with the use of web components. The disadvantage that Vaadin potentially has as a server technology is related to the limited number of competing users. However, the study https:// vaadin.com/vaadin-scalability-report reports the performance which is quite acceptable for midsize business systems. Conforming to Servlet API technologies allows the use of any application server that supports Servlet technology. In this specific case, the WildFly (formerly JBoss) server, a Red Hat open-source distribution, is used [20]. Hibernate was chosen as the ORM mapper due to its stability, large user base, and continuous development, as well as compliance with the JPA specification. Additional libraries for working with Excel, and XML files are from the Apache Foundation, while the JasperReports tool is chosen for report generation.



Figure 4 - Usage of web components.

6. CONCLUDING CONSIDERATIONS

BAB Framework is a software pattern that aims to accelerate the development of business information systems. It is based on an object-oriented approach and the design pattern concept. The BAB model is implemented using the Java programming language and the Jakarta EE, with functional programming in the business logic layer. The proposed solution is continuously evaluated by developing and maintaining the operative business information system of medium complexity. The results show that BAB Framework significantly accelerated the development process, reduced the workload and fatigue of programmers, improved code readability, and facilitated testing. One of the main BAB framework's deficiencies is the steep learning curve for programmers, as they must remember many conventions to describe the structure and functionality of the system. A domainspecific language, a code generator, and a graphical UML-based tool are under development to address the issue. Another deficiency is the significant effort needed to configure the infrastructure (operating system, database, and web servers), which can be time-consuming and/or require the commitment of specialized personnel. Container technology, like Docker, is envisioned to simplify configuration and ensure continuous delivery. Apart from the above-mentioned issues that are obvious and require short-term resolution, there is plenty of space for substantial improvement of the BAB Framework. Meta modeling enhanced with appropriate AI techniques (i.e., semantic technologies for semantic coupling and co-change of software components [21], explainable AI for defect prediction models [22], large language models [23] for automated models and/or code generation, and alike) is the road that should be hit in the future to improve substantially of the BAB Framework.

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SINTEZA 2023

INFORMATION TECHNOLOGY SESSION

eHEALTHCARE SECURITY CONCEPT BASED ON PKI AND BLOCKCHAIN TECHNOLOGY

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Abstract:

Technological advances in information and communication technologies induce the inevitable automation of life processes. The transition of social and business activities to cyberspace has brought a new quality to everyday life, but at the same time, it has produced new challenges in the field of data protection. One of the areas where this issue is particularly sensitive is the field of healthcare. Unauthorized access to a patient's data can cause many almost insurmountable problems in life, ranging from theft and identity abuse to putting them in an unequal life situation compared to insurance companies, credit and banking systems, transportation systems, and many other life situations. In this paper, the concept of eHealthcare data protection based on PKI and Blockchain technology is proposed. PKI technology ensures reliable identification of all entities in the system by applying digital certificates of the appropriate type and controlling data integrity at the time of creation. Blockchain technology ensures the integrity of data in time in the sense that data entered into the blockchain cannot be changed, deleted, or inserted into new ones without violating a chaining structure.

Finally, it was shown that the electronic healthcare information system based on these principles is compatible with the GDPR of the European Union. The proposed principles are also in line with the main directions of designing secure information systems known under the name zero trust information systems.

Keywords:

eHealthcare, Information Security, PKI, Blockchain, Digital Certificate.

INTRODUCTION

Technological advances made in the past few decades in the field of information and communication technologies, sensors, microprocessor devices, and the application of software solutions and artificial intelligence have enabled tremendous progress in people's daily lives. By transferring business and life processes into the digital space, a symbiosis of machines and people was formed - Cyberspace. Progress is reflected in the efficiency of the implementation of processes, reducing their costs and the necessary time for implementation. Digitalization of business and life processes as an essential prerequisite has an unambiguous identification of participants and their rights to participate in this process.

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In this context, the challenges of information security within these processes come into play. An impressive example of this is the healthcare system [1].

In the healthcare system data collection, storage, and processing, as well as in all complex systems, is the basis of their functioning. Data are collected on patients, their ailments, the results of medical procedures, treatment, and the results of therapeutic procedures. In addition, records of personnel in the system and their role, services provided and charged, the state of resources and medical infrastructure, and many other data are kept. Managing this data is a serious challenge from the point of view of its role, privacy, and availability. Therefore, information security plays an essential role in this system because it ensures confidentiality, integrity, and availability of data. Confidentiality protects the identity of the user and his medical data as well as all the sensitive data of the healthcare system. Integrity achieves credibility of registered data and availability ensures access to data and resources at the time they are needed. For the realization of these functionalities, it is essential to have reliable and verifiable electronic identities, manage them and ensure data integrity.

This paper presents the concept of information security in healthcare systems based on digital certificates as a method of identification of entities and Blockchain technology as a means of maintaining the integrity of information in communications and time.

The paper consists of an introduction after which, in the second part, the nature of information in the infrastructure information system is discussed, the importance of their protection, and the preservation of their integrity. This section describes techniques for identifying and preserving data integrity relevant to this concept. The third part describes the concept of protection of the information healthcare system and the scenario of its implementation. In the end, the security characteristics of the proposed concept are presented. In the final part of the paper, a conclusion is given and then the references used in this paper are listed.

2. E-HEALTHCARE INFORMATION AND SECURITY

An electronic healthcare system is created by applying Information and Communication Technologies in the process of healthcare. This involves networking of medical sensors, devices, and entities in the healthcare system to more efficiently collect information, and apply business, patient surveillance, and health procedures.

For an individual to enjoy health care, they must agree to the collection and use of necessary information as part of medical procedures, such as test results, medical staff notes, or even the use of technological devices that allow patients to register their health status in the process of examination, self-monitoring or treatment [2]. This information, to a greater extent, is collected by professionals, organizations, and the state administration for research purposes, necessary administration, and other business reasons. As can be seen, it is private patient data, and unauthorized access to such information can be harmful to both the person and the system. In many cases, scammers or cybercriminals exploit health data to create false identities to buy medicines, medical equipment, and even health insurance fraud [3]. On the other hand, there is an objective need to access these data not only for the treatment of the patient but also for the needs of the state administration, research projects, and more. This approach must be strictly controlled and under the conditions regulated by law and this is the point at which information security comes into play.

A modern approach in the organization of health care is directed towards the patient and the patient directly decides on the use of personal medical data, [4]. This approach is fully in line with the basic postulates of modern data and information systems protection based on the approach that each entity (devices, people, software, and hardware) has a unique identification in the health information system. The system keeps precise records of who, when, and what did so that in the event of incident detection, the system's operating records enable the responsible entities identification and undertake the necessary recovery activities. For records to be credible in an electronic health system, all entities must possess a unique identity that cannot be falsified and the record of events in the system must be so realized that it is impossible to falsify it in the sense of unauthorized changes.

This paper will present the concept of a security solution based on asymmetric cryptography and digital electronic certificates as a way to establish a unique electronic identity in the digital world and blockchain technology for securing and verifying the integrity of data.

2.1. DIGITAL IDENTITY AND PKI

To realize any form of organization in the electronic world, it is necessary to have mechanisms for identifying and distinguishing the entities that makeup it. The discovery of asymmetric cryptography created the conditions for creating electronic identities using digital certificates, [5], [6]. The identity of the entities in the system (people, devices, software) is defined by the public key of the selected asymmetric cryptographic algorithm. Correspondence between the physical identity of an entity and its electronic identity is achieved by issuing a digital certificate that establishes a unique link between physical and electronic identity. Digital certificates are issued by an authorized certification authority within the legally identifiable public key infrastructure (PKI). The accuracy and integrity of the data contained in the digital certificate are guaranteed by the certification body that issues the digital certificate with its electronic signature. Hence it follows that one entity may belong to multiple PKI systems and for the sake of interoperability there should be a standardized model of issuance and format of electronic certificates. To this end, standard digital certificate formats used in the digital world have been defined, for example, ITU-T X.509, ISO/IEC 9594-8, [7]. The profile of the digital certificate according to this standard is shown in Table 1 (a).

As we have mentioned earlier, a health information system is a complex information system of heterogeneous devices (sensors, wearable devices, various types of mobile devices, complex medical devices...) so the application of this universal standardization carries with it several conditionally stated difficulties:

- The size of a standard digital certificate is about two kilobytes, [8]; and
- Digital certificates under this standard, in general, can have a very complex structure due to recursive definitions in the standard and potentially pose a problem for devices with limited resources (sensors, mobile devices ...) in terms of memory and available energy.

To overcome these problems in [8], [9] a different digital certificate profile has been proposed based on the idea of reducing the complexity of the description and consequently the need for smaller storage memory and power for processing. The main characteristics of the described CBOR, [10], profile are given by:

- The proposed profile is compatible with X.509.V3;
- A fixed asymmetric algorithm (ECDSA With SHA256) is used for electronic signature; and
- All entity names are explicit, simpler than allowed naming per X.500 standard

The CBOR certificate profile format is shown in Table 1 (b).

(a)			
Standard X.509 certificate profile			
Field		Content description	
Version		X.509 Version of certificate	
Serial Number		Serial number of the certificate	
Signature Algorithm ID		Identification of the signature algorithm	
Issuer (CA) name		X.500 Name of the certificate issuer	
Validity Period		(beginning date, ending date)	
Subject name		Certificate owner X.500 name	
Subject Public Key Info	Algorithm ID	Public key algorithm ID	
	Public Key Value	Value of the public key	
Issuer Unique ID		Identification of the certificate issuer	
Subject Unique ID		Identification of the certificate owner	
Extension		Additional information	
CA Digital Signature		Digital signature of the certificate by CA	

Table 1 - Certificate profile format.

(b)			
CBOR X.509 certificate profile for IoT			
Field	Content description		
Version	Fixed to 3		
Serial Number	Unsigned integer		
Signature Algorithm	ECDSA With SHA256		
Issuer (CA) name	EUI-64 as UTF8 String		
Validity Period	UTCTime		
Subject name	EUI-64 as UTF8 String		
Public Key Value	ecPublicKey followed by secp256r1 and 64-byte uncompressed ECC public key		
Issuer Unique ID	Not present		
Subject Unique ID	Not present		
Extension	Additional information		
CA Digital Signature	ECDSA With SHA256 Sig value		

The management of this type of certificate can theoretically take place in the same way as the management of certificates according to the X.509 V3 standard. This is supported by the fact that these devices are applied in the health system and at the time of use must have connectivity to the system

2.2. BLOCKCHAIN TECHNOLOGY

Blockchain technology in the literature has different definitions but can best be described from the point of view of data structures as a linked list of blocks of data that form a collection of records called a Ledger. The Ledger is not stored in a classic way as a memory object or a static database but is an object that is stored as its multiple copies within different computers/information systems, possibly geographically distant. Synchronization and integrity of data in the Ledger are realized by applying the protocol for managing the blocks, the way of creating new blocks, and the conditions of their entry in the Ledger list. These protocols based on the use of cryptographic mechanisms ensure the integrity of the blocks constructed in such a way that it is almost impossible to falsify/change the Ledger and enter unverified data into it. Any attempt to enter incorrect blocks in the Ledger is easily detected and the entry of such blocks in the list is not allowed. Connecting data blocks in a specific way with the use of cryptographic electronic signature mechanisms and hash functions allow powerful protection of the integrity of the Ledger [11], [12].

The method of entering blocks in Ledger can be recognized as

- 1. public blockchains;
- 2. private blockchains;
- 3. consortium blockchains; and
- 4. hybrid blockchains.

2.2.1. Block structure

Each block has two separate parts one part consists of the transaction/data that the block contains and the second part of the block makes up its header. Each transaction/data is electronically signed by the transaction initiator and by the transaction/data creator. The block header consists of the following fields:

- Merkel hash represents the hash value of all transactions carried by a block and allows you to easily and quickly check whether a transaction belongs to the block or not;
- The hash value of the previous block represents the hash value of the header of the previous block and the control data to check the integrity of the previous block;
- A timestamp is data on the time of the creation of a block that is electronically signed by the competent authority; and
- The system weight factor and random value are the data involved in reaching a consensus on whether a newly formed block is valid for entry in a bookkeeping list.



Figure 1 - Illustration for block structure and blockchain, [13].

2.2.2. Creating correct blocks for entry in the Ledger

The data contained in the transaction part of the block may be different by its nature and may also have different origins and storage locations.

2.2.2.1. Entering a block in a public blockchain

The data source is available to all entities that want to try to form a list entry block and the process proceeds as follows:

- The creator of the candidate block selects from the data set a certain number of data to include in the block as data. She then constructs their Merkel hash and writes the time in the timestamp field;
- 2. In the hash value box of the previous block, writes the hash value of the previous block;
- 3. In the field for the weight factor enters its value;
- 4. It selects a random number, at its discretion, and writes it into a random value field; and
- 5. The hash function calculates the hash value of the candidate block header. If the resulting value is less than the weight factor, the creator has found the correct block and forwarded it to the community for verification. If the value is not less than the weight factor, it goes back to step 4.

When other members of the community receive a candidate for admission to the linked list, they conduct a check on him or her as follows:

- Check whether the hash field of the previous block contains the hash value of the last block entered in the sheet. This prevents inconsistent copies of a linked list from appearing. If the check is negative, the candidate is discarded;
- 2. It is checked whether all data contained in the candidate block exists in the data source and if not, the candidate is discarded as defective;
- 3. The value of Merkel's hash for the bloc is checked and if the check is negative, the candidate is rejected;
- 4. It is checked whether the hash value of the block header is less than the weight ingestion factor. If the check is negative, the candidate is discarded; and
- 5. If all checks are positive, the block is written to the linked list, and the data that makes it up is deleted from the data source.

The process of constructing a block so that its hash value is less than the weight factor is called Proof-ofwork and is proof that the block is formed correctly. In digital currency systems, constructors of the correct blocks that are entered in the linked list receive financial compensation. For details about various mechanisms created block credibility see [11].

2.2.2.2. Entering block in private blockchain

In private blockchains, the mechanism of registering new blocks differs in that it is not necessary to reach a community consensus on the correctness of the block, but the role of verifying the validity of the block is entrusted to authorized entities. This achieves administrator control over the blockchain and significantly improves the performance of block entry into the blockchain.

The blockchain consortium represents the integration of public and private blockchains in terms of connecting their good properties and hybrids, as its name suggests, the integration of elements of previous models.

3. E-HEALTHCARE SECURITY CONCEPT

The electronic health system is network-oriented in the sense that it involves collecting data, processing it, and exchanging it between different entities, often geographically distant, to achieve the best possible results. The basic element of the electronic health system is the electronic record of health data (EHR). The data contained in the EHR are primarily used for the health care of the individual to whom they relate. Their secondary use refers to their social usability, the need for application in medical research, the improvement of the scope and level of health care, and the reduction of costs in the functioning of the health system. These two aspects further point to the need for strong security and privacy mechanisms in electronic health systems so that access to and compliance with legal regulations in the management of the data subject can be strongly controlled. For the desired high levels of access control and management, it is essential to distinguish between all elements in the system. This is achieved by defining methods of identifying the factors of the system and assigning a unique identifier to each of them, [14].

3.1. ENTITY IDENTIFICATION

Bearing in mind that digitalization is strongly represented in many countries, including ours, a legal regulation has been developed that regulates the way of assigning electronic identities to people so that electronic transactions are unambiguously and undeniably recognized in business and legal processes. Therefore, in the electronic health insurance system, they are identified by the public key of the selected asymmetric cryptographic algorithm and a qualified digital certificate in the format X.509v3 that confirms the connection between the person and the assigned public key. A qualified certificate is issued under the legal regulations of the environment in which the system is implemented.

Each person, user of the electronic healthcare system has a smart card, and an e-health patient ID (eHPID), and every person belonging to the electronic healthcare system has an identification card (eHID).

The records of users of the electronic health system, patients, are formed and stored within a protected database, for example, basic identification data are stored in cryptographically protected form. The system members' records are kept in another protected database.

Devices in the system are assigned identities represented by a public key related to the elliptical curve SECP256R1 and the electronic and physical identity of the device are connected by a digital certificate in CBOR format.

In this context, all entities participating in the electronic health system have unique electronic identities, [15], [16]. This way of establishing identity enables effective protection of the privacy of patients' data.

3.2. MEDICAL EXAMINATION AND RESULT EVIDENCE AND RECORD

Let's consider the following simplified scenario, as an illustration of the concept. The patient has a health problem and comes to the primary health institution for consultation with a physician. The review procedure takes place as follows:

- In the physician's office, the physician and the patient using their eHPID and eHID card are presented to the system;
 - a. If the physician and the patient are recognized as a legitimate user of the health care system, the physician is allowed to open the patient's EHR and create a new examination

record identification number and enter data on problems and conclusions about the treatment;

- b. If the process of diagnosis and therapeutic determination is completed at this level, the doctor prescribes therapy, the system determines the identification number of the generated prescription.
- 2. If the medical indications are such that additional medical tests need to be carried out for each additional medical examination the physician generates a request with the necessary data;
- 3. Each prescription and request for additional medical examinations individually is digitally signed by the physician. Each electronically signed prescription/request for additional medical examinations constitutes a medical transaction and is placed in the appropriate blockchain; and
- 4. Prescription and medical procedure identification numbers are recorded in the patient's medical history blockchain. The patient's medical history blockchain is identified by a unique numerical identifier that exists only in a protected database containing the patient's identification data.

Conceptually, this way of creating and managing medical records enables the independent existence of medical data from the identity of the patient whose interaction with the system they were created. The only link between the patient's identity and his medical history is the blockchain identifier of his medical history, which is stored in a protected database the register of users of the health system. The concept of the system is shown in Figure 2.



Figure 2 – General concept of blockchain technology in healthcare, [17].

3.3. SECURITY ANALYSIS

Given the complexity and importance of a healthcare system for every community its safety and reliability of functioning are essential for any organized society. By transferring procedures and data into a digital world, in addition to the existing challenges, all those security challenges that the processes in cyberspace carry with them have entered the game. In this way, technological improvements simultaneously contribute to the quality of systems and services on the one hand and impose security challenges on the other.

Given the security incidents related to patient data privacy, the first component we will consider is the proposed model of entity identification in the system.

The electronic identity of each entity is defined by the assigned to it reliable electronic certificate. In this way, conditions were created for reliable identification, authentication, and authorization of entities in the system. A reliable identification mechanism, such as this proposed one, allows unique recording and tracking of system events and detects and prevent any activity of an entity that does not comply with the role assigned to it in the system. In this way, the role of monitoring the operation of the system and supporting the reliability and proper operation of the system is achieved.

But as previously stated in safety terms, the basic security problem in the health information system is the collection, use, and management of patient data. The system must be organized in such a way that, without collision, it allows the primary and secondary use of the patient's medical data without compromising his privacy. Additional use, storage, and management of this data must be implemented in such a way as to preserve its privacy and integrity.

In the proposed concept, the patient's identification data are located only and exclusively in a protected database that can only be accessed under defined conditions for example with the patient's consent demonstrated by reading his eHPID document. The registration record in the database of users of the health system also contains a static numerical identifier of the patient that is identified in medical procedures and records in a vase with them. The use of numerical identifiers in medical reports and therapeutic procedures allows the use of this data without infringing on the patient's privacy rights.

Patient data privacy is guaranteed by the applied method of establishing randomized numerical identification of patient medical documentation blockchain. That numerical identification is stored in the protected database of the healthcare system patient record and represents the only connection between patient medical data and its identity. Access to that numerical identification is possible only using the patient's eHPID smart card. The situation when a patient on his own will allow usage of his eHPID, for example giving physical access to it or entering a PIN number, will be recognized as his consent to access his medical data. The anonymity of the patient regarding requested medical procedures and prescribed health care therapy and medicine is achieved by their randomized numerical identification which is described in the paper's second part. The integrity of medical examination requests and reports is guaranteed by the digital signatures made by the initiators of medical and therapeutic procedures, and report creators. Data integrity over time is achieved by their storage in the appropriate blockchain.

This analysis shows that the proposed concept meets the primary security requirements of the health insurance information system, which is to preserve the privacy, integrity, and availability of medical data with their primary and secondary use.

4. CONCLUSION

Technological advances and orientation towards a digitized society by transferring social and business interactions into cyberspace have greatly improved everyday life. At the same time, this change has brought inevitable challenges in the field of information security. One of the largest is the establishment and reliable exploitation of the electronic healthcare system. In this paper, a safety concept for electronic health systems is proposed. The concept is based on reliable identification by digital certificates within the legal PKI infrastructure. The system recognizes two types of certificates, qualified for people in the format X.509V3 and CBOR [10] for devices and software taking into account the existence of devices with limited resources. In this way, each entity becomes unambiguously recognizable in the system. In security terms, by these following objectives are achieved:

- Undeniable record of events in the system, their analysis, and establishment of responsibility in the event of an incident as well as analysis and undertaking of activities to prevent security incidents in the future;
- 2. The establishment of an unambiguous identity enables the realization of such a way of recording the patient's medical data, which ensures the primary and secondary use of medical data in a way that does not endanger patient privacy; and
- 3. Registering medical information and system data by applying digital signing and blockchain technology, ensures that data integrity is preserved at the time of creation and during the time.

Achieving the stated goals is the foundation for compliance with the EU GDPR [18] and an inevitable basis for the implementation of zero-trust information systems [19], [20], [21].

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INFORMATION TECHNOLOGY SESSION

CREATION OF STRUCTURED FORMATTED DATABASE FOR ALUMNI PROJECT

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Abstract:

An Alumni club, made up of former students, has been working at several prestigious Faculties of the University of Belgrade for a long time. Thanks to the contacts through this organization, as well as the help of former students of these Faculties, a large number of newly graduated students received useful advice first-hand, as well as the possibility of employment in successful companies in the country and abroad. The Academy of Applied Technical Studies Belgrade followed this example and formed Alumni Clubs in its departments and sections. In this way, the Alumni Club started working in the Computer-Mechanical Engineering Section. It took time for students who had graduated a long time ago to sign up for the club, but the response of students is getting bigger and bigger, so the need to create a database and appropriate applications emerged. A database in SQL server is created, after which advanced and automated queries for obtaining relevant data are developed in form of stored procedures.

This paper presents two approaches to creating a formatted database in XML language, in order to enable better connection with the most popular programming languages such as Java, ASP.NET, C#, ColdFusion and others. In the first approach, selecting the appropriate button creates an XML document, and in the second approach filling in the text fields in the application, which is developed in the C# programming language, leads to its creation.

Keywords:

Database, XML, Alumni, Programming.

INTRODUCTION

The goal of forming the Alumni organization is to establish and maintain a connection between the Faculty and graduate students, as well as to encourage cooperation between the Faculty, companies and organizations in which they are employed, [1]. Former students can influence the design of the Faculty's development strategy; influence the profiling of new curricula, and assist in marketing and the promotion of the Faculty itself. It should be emphasized the importance of cooperation between the Faculty and companies where former students work, in terms of drawing the attention of potential employers to the employment of future graduates, [2] The task of the Alumni Club of the Computer-Mechanical Engineering Section is to enable the continuation of socialization established during the studies, and to contribute to the strengthening of the profession. The other important task is to provide assistance to graduate students, and to establish active and constant cooperation between the Computer-Mechanical Engineering Section on the one hand, and the economy and society on the other.

The Computer-Mechanical Engineering Section wants to establish a permanent relationship with its graduate students, and inform them about all development plans and education programs, and include all those who want to help the development of this Department or Section. In this sense, communication with graduate students is crucial, not only related to their wishes and needs (studying or finding a job), but also their thinking about the study itself (their suggestions and remarks). The Alumni Club of the Computer-Mechanical Engineering Section establishes and maintains a connection between the Department and its students after graduation, connects all former students through socializing and exchange of experiences, develops cooperation between the Department and companies or organizations where former students work, exchanges professional and business information between association members, establishes cooperation with other Alumni organizations from the country and the region, provides advisory support from graduated students and enables the implementation of more effective scientific and research work, connects students and the business community, provides assistance in the employment of association members.

Considering that the number of members of the Alumni Club is growing more and more, it is necessary to automate the entire procedure and create an appropriate application. To develop the application for entering, deleting, updating and searching new members, the C# programming language was chosen [3]. Manipulation with data is much better with stored procedures and advanced queries and an administrator has the opportunity to get valid and specific types of data regarding Alumni members. Implementation of stored procedures for creating the Alumni database is developed and shown in [4]. This paper shows data storage in a text-structured format using the XML language.

2. THE FIRST APPROACH TO CREATING AN ALUMNI XML FILE

Extensible Markup Language (XML) is widely used as an alternative to a database, as well as for storing application configuration information. XML has a similar syntax to the HTML language, [5]. The XML language begins with the declaration <?xml version="1.0"?>, indicating that the document uses XML code, as well as the appropriate text encoding method. An XML document consist of XML elements which consists of an input character, a closing character, and data or so-called child elements between the input and output characters. Any name for the elements can be used, but care should be taken to be case-sensitive, as well as the fact that XML ignores spaces so that the XML file can be written in one line, [6]-[7]. Tabs can be used because spaces between elements can be ignored. XML is casesensitive, and no special characters can be used in the content.

XML documents must take into account the order of elements and the data type of individual elements. The scope disambiguates the displayed elements by determining which language a particular element belongs to, [8].

XML documents are formed as tree elements. The XML tree starts with the root element and then moves to child elements. To identify the scope, a prefix is introduced by entering a colon and the character that indicates the prefix, [9].

In the .NET framework, there are classes that can read and operate on XML documents. These classes are located in the System.Xml namespace, [10]. The model used is the XML Document Object Model, which represents a set of classes that represent different parts of an XML document, [11].

The xmlTextWriter class is used to write XML files. Some of the methods used are given by:

- WriteStartDocument writes the string <?xml version="1.0">;
- WriteStartElement writes the tag to open the element;
- WriteEndElement writes the tag to close the element;
- WriteAttributeString writes the attribute for the element;
- WriteString writes the data for the element as a string;
- WriteElementString writes an element and its string data;
- WriteComment writes a comment;
- WriteCData- writes the CData part;
- Flush- empty the contents of the printer; and
- Close closes the xmlTextWriter.
The properties of this class are shown by:

- Formatting- sets to how the file should be formatted, and can be Formatting.Intended or Formatting.None, which is the default;
- Indentation- gives how much each sub-element is indented; and
- WriteElementString writes the start tag, data, and end tag, and automatically writes the trailing element.

The xmlTextWriter and xmlTextReader classes behave in the same way as SteamReader and SteamWriter. The listing below, Listing 1, shows how to create an XML file as a structured formatted database with the members of the Alumni Club. By selecting the "Create Alumni XML file" button, in the Alumni application the alumni.xml file will be created.

The xmlTextReader class is used to read the alumni XML file. The listing further shown (Listing 2) presents how to read the file with the members of the Alumni Club, and it is a fragment of complete listing.

```
xmlTextWriter xmlCreate=new xmlTextWriter(Server.MapPath(alumni.xml), null);
xmlCreate.Formatting=Formatting.Indented;
xmlCreate.WriteStartElement("Alumni");
xmlCreate.WriteComment("This file is created by using xmltext writer class");
xmlCreate.WriteStartElement("AlumniMember");
xmlCreate.WriteAttributeString("ID", "1");
xmlCreate.WriteAttributeString("Name", "Nemad");
xmlCreate.WriteAttributeString("LastName", "Nemadovic");
xmlCreate.WriteAttributeString("Sex", "Male");
xmlCreate.WriteAttributeString("Place", "Zrenjanin");
xmlCreate.WriteAttributeString("Date", "2/1/2019");
xmlCreate.WriteAttributeString("Email", "nnenadovic@gmail.com");
xmlCreate.WriteAttributeString("Profession", "Administrator");
xmlCreate.WriteAttributeString("Employed", "Yes");
xmlCreate.WriteAttributeString("Attainment", "Master of Science");
xmlCreate.WriteEndElement();
xmlCreate.WriteEndElement();
xmlCreate.WriteEndDocument();
xmlCreate.Close();
```

```
Listing 1 - Creation of XML file with Alumni members.
```

```
xmlTextReader xmlReader=new(Server.MapPath(alumni.xml), null);
while(xmlReader.Read())
if(xmlReader.NodeType == xmlNodeType.Element)
{
    Response.Write("<b>Element:</b>" + xmlReader.Name);
```

Listing 2 - Reading of XML file with Alumni members.

The properties of the xmlTextReader class are:

- Name gives a value to the current node;
- Depth shows the depth in the XML tree;
- Value gives the value of the current node;
- Item gives the value of the Attribute;
- EDF if we are at the end of the file the value is True; and
- NodeType shows the current node type.

The node types in the xmlNodeType enumeration are:

- Element represents the initial tag of an XML element;
- EndElement represents the closing tag of an XML element;
- CDATA part of the XML node;
- Text displays text data in an XML node;
- WhiteSpace white sign between nodes; and
- xmlDeclaration XML header.

3. THE SECOND APPROACH TO CREATING AN ALUMNI XML FILE

The other approach includes the creation of an application developed in C# programming language. A form for inserting new members of the Alumni Club is presented in Figure 1.

When the Add Alumni Member button is selected, a new xmlDocument is created. That document is written to the file specified by the private PATH field. It is then tested whether the file already exists using the Exists method of the System.IO.File class. If the file does not exist, then a new file is created and the first record is added.

The code below creates the necessary nodes that are added to the Xml document. First, an Xml Declaration is created using the xmlDeclaration class and the Createxml-Declaration method. This method uses three parameters; version, encoding, and whether the file is standalone.

It then creates a comment using the xmlComment class and the CreateComment method and passes the text to the method used in the comment. After that, the root element is created using the CreateElement method and the xmlElement class. The CreateElement method is used to create the root, parent, and child elements. This method takes a single argument as a string representing

NAME		
LAST NAME		
SEX		
PLACE		
DATE	Add Alumni Member	
EMAIL		
PROFESSION		
EMPLOYED		
STUDYPROGRAM		
ATTAINMENT		

Figure 1 - A form for inserting new Alumni member.

the name of the given element.

An Alumni element is created and stores the data entered by the user. The Alumni element has one name attribute, while the other elements are children. The CreateAttribute method accepts one argument representing the name of the attribute. Attribute details are stored in the xmlAttribute object. Using the AppendChild method adds a declaration to the xmlDocument and adds it as the last child element to the document. Then a comment is added immediately below the declaration. Then it starts with the root element and the child elements.

Reading content from XML files is a necessary technique that is used a lot in the case of saving configuration settings that are usually placed in an XML file and then used when loading an application. The special query language XPath is used to select nodes in an XML document. Using this language, it is not necessary to search the entire tree of XML nodes. The two methods used to select nodes in the XPath programming language are xmlNode.SelectNodes() and xmlNode.SelectSingleNode(). The SelectNodes() method displays an xmlNodeList containing all nodes that match the XPath string.

A part of the code is presented in the following listing – Listing 3.

```
private XmlDocument doc;
private const string Path = @"D:\alumni.xml
private void btnAddAlumniMember Click(object sender, EventArgs e)
{
    //Create XML document
    doc = new XmlDocument();
    if (!System.IO.File.Exists(PATH))
    {
        XmlDeclaration declaration = doc.CreateXmlDeclaration("1.0","UTF-8", "yes");
        XmlElement root = doc.CreateElement("Alumni");
        XmlElement alumnimember = doc.CreateElement("AlumniMember");
        XmlAttribute name = doc.CreateAttribute("Name");
        XmlElement lastname = doc.CreateElement("LastName");
        XmlElement sex = doc.CreateElement("Sex");
        XmlElement place = doc.CreateElement("Place");
        XmlElement date = doc.CreateElement("Date");
        XmlElement email = doc.CreateElement("Email");
        // Add values to each node
        name.InnerText = txtName.Text;
        lastname.InnerText = txtLastName.Text;
        sex.InnerText = txtSex.Text;
        place.InnerText = txtPlace.Text;
        date.InnerText = txtDate.Text;
        email.InnerText = txtEmail.Text;
        profession.InnerText = txtProfession.Text;
        employed.InnerText = txtEmployed.Text;
        studyprogram.InnerText = txtStudyProgram.Text;
        attainment.InnerText = txtAttainment.Text;
        // Create document
        doc.AppendChild(declaration);
        doc.AppendChild(comment);
        doc.AppendChild(root);
        root.AppendChild(alumnimember);
        student.Attributes.Append(name);
        student.AppendChild(lastname);
        student.AppendChild(sex);
        student.AppendChild(place);
        student.AppendChild(date);
        student.AppendChild(email);
        student.AppendChild(profession);
        student.AppendChild(employed);
        student.AppendChild(studyprogram);
        student.AppendChild(attainment);
        doc.Save(PATH);
      }
```

}

98

Listing 3 - Creation of XML file with Alumni members from application in C#.

4. CONCLUSION

Taking into account that the number of members of the Computer-Mechanical Engineering Section is constantly growing, it was necessary to create a database for easier data manipulation. The database was created using a SQL server; advanced queries were used, as well as stored procedures, suitable for obtaining various statistical data and other relevant indicators.

This paper shows the creation of an XML file in two ways, by directly selecting an appropriate button, and through the application developed in C#, by entering desired data into text boxes. The chosen XML format enables even more successful data processing due to its use in all programming languages and platforms, as an opportunity to create a stable Web application. For differently formatted XML files, text files, and other formats, it is used XSL language. This language is primarily used to transform XML files into HTML, where the transformation process takes place automatically.

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INFORMATION TECHNOLOGY SESSION

MONOCULAR DEPTH ESTIMATION USING STATE-OF-THE-ART ALGORITHMS: A REVIEW

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Abstract:

Monocular Depth Estimation is the process of calculating the depth value of each pixel given a single RGB image. This challenging computer vision task is the main prerequisite for determining scene understanding for applications such as 3D scene reconstruction, augmented and virtual reality. Additionally, a lot of robotics issues, like mapping, localization, and obstacle avoidance for terrestrial and aerial vehicles, depend on depth information. Five monocular depth estimation techniques are compared. This comparison focuses on how generalizable the methods are. According to this study, monocular depth estimation techniques frequently exhibit artifacts when used on images that are not part of the training set, despite performing well on images that are similar to the training images. We test the various approaches using photos that resemble training data as well as paintings or images with odd perspectives.

Keywords:

Depth Estimation, Monocular Depth Estimation, Computer Vision, Deep Learning, Comparison.

INTRODUCTION

Monocular depth estimation (MDE) is a very useful technique in situations where we cannot use sensors and stereo vision to obtain a dense depth map. Instead, we can determine the depth from an ordinary RGB image. It's much cheaper than using expensive equipment and takes less time. In this paper, we compared five methods that are most often used for depth estimation. All models are available online and are free to use and modify. In the first five chapters of this paper, the used algorithms are briefly described and at the end, their applications are presented side by side using different images.

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2. ADAPTIVE BINS - ADABINS

Believing that global processing is a lot more powerful when done at high resolution than once the tensors reach a low spatial resolution at or near the bottleneck, the idea of AdaBins is to perform a global statistical analysis of the output of traditional encoder-decoder architecture and to refine the results with a learned postprocessing building block that operates at the highest resolution [1]. Authors proposed the analysis and modification of distributions of the depth values. Depth distribution can vary for each image. For example, if we have a picture of an object which is very close to camera, the depth values will be distributed over a very small range. In contrary, if we have a corridor, depth range will go as far as the maximum depth supported by the network. Using AdaBins, depth range is divided into bins where the bin widths changes based on image. The final depth estimation is a linear combination of the bin center values. EfficientNet B5 [2] is used as a backbone for the encoder. With standard feature upsampling decoder [3], it makes a first component of architecture. The second part is proposed adaptive bin-width estimator AdaBins which is based on a transformer [4] that predicts both bin widths and the probability of each pixel to belong to a given bin [1]. Loss function that gave best results is calculated as a summary of Pixel-wise depth loss [5] and Bin-center density loss multiplied by 0.1 for all experiments. Datasets that are used for training are NYU Depth v2 [6], KITTI [7] and SUN RGB-G [8].

3. MIXING DATASETS FOR ZERO-SHOT CROSS-DATASET TRANSFER - MIDAS

The idea behind this approach is to use variety of different datasets for training and testing, because none of the existing datasets is that sufficient and diverse to represent a complete real-world images. In contrary, multiple datasets are complement to each other [9]. Authors made their models and code available on their GitHub (https://github.com/isl-org/MiDaS) where you can download pretrained weights. Models were trained on up to 12 datasets (IRS [10], MegaDepth [11], ApolloScape [12], NYU Depth V2 [6], BlendedMVS [13], DIML [14], HRWSI [15], TartanAir [16], ReDWeb [17], 3D Movies, WSVD [18], KITTI [7]) with multiobjective optimization. Experimental protocol used here is zero-shot cross-dataset transfer and it stands for using different datasets for training and testing instead of using subset of one data collection.

There are also used different encoder-decoder architectures such as ResNet-50 [19], ResNeXt-101 [20] or DenseNet-161 [21].

4. DENSE PREDICTION TRANSFORMER

Many of existing architectures for dense prediction are based on CNNs. These architectures are made of encoder, which is based on an image classification network so called "backbone" like ImageNet [22], and decoder that aggregates features from the encoder and converts them to the final dense predictions [23]. This approach has many disadvantages such as the choice of backbone and convolutional image downsampling. There are some work arounds for these issues such as training at higher input resolutions, dilated convolutions [24] or connecting multi-resolution representations in parallel throughout the network [25]. However, convolution is still a bottleneck for prediction quality. Therefore, authors in their work [22] introduced the use of dense prediction transformer (DPT) which changes the base architecture to a transformer based encoderdecoder. Also, they used vision transformer (ViT) [26] as a backbone. There are two models that extend MiDaS with pre-trained weights. The code is available on their GitHub (https://github.com/isl-org/DPT).

5. GLOBAL-LOCAL PATH NETWORKS

This method introduces a new architecture and training strategy to further improve the prediction accuracy of the network [27]. GLPDepth uses a transformer based encoder-decoder. The major improvement over other methods is the use of a newly proposed data augmentation trick called "Vertical CutDepth" [28] which enhances the original CutDepth [29] by preserving the vertical geometric information. By maintaining the vertical range of the input image, the network can capture the long-range vertical direction for better prediction [27]. Training loss used in this model is Scaleinvariant log scale loss [30]. Datasets NYU Depth v2 [6] and SUN RGB-D [8] are used for validation and evaluation of pre-trained models.

6. ADELAIDEPTH

AdelaiDepth is an open-source toolbox for monocular depth prediction. Algorithms are available on their GitHub (https://github.com/aim-uofa/AdelaiDepth). There are Boosting Depth [31], 3D Scene Shape [32], DiverseDepth [33] [34], Virtual Normal [35], and Depth Estimation Using Deep Convolutional Neural Fields [36] algorithms. In our paper, we will use 3D Scene Shape which offers model weights for ResNet-50 [19] and ResNeXt-101 [20] backbone. The architecture is based on an encoder-decoder, and the network is trained on multiple datasets such as DIML [14], HRWSI [15], Taskonomy [37], 3D Ken Burns [38], and Holopix50K [39]. During training, three losses are combined which are, respectively, Image-level normalized regression loss, Pairwise normal loss, and Multiscale gradient loss. 3D Scene Shape also studies the problem of creating a 3D model from the estimated depth map, and that predicted model is used during the training process in order to regularize the monocular depth prediction module using the surface normals of the estimated 3D shape [28].

7. COMPARISON

In this chapter, we will present our results. We used various pictures in our experiments, but here we will present just a few of them in order to understand the limits and generalization capabilities of each model. We used natural images, synthetic or non-natural, and ambiguous images. The comparison is done by using the magma colormap (see Figure 1). Fine-tuning is not done, because we wanted to simply compare basic methods that are parameters-free.



Figure 1 - Magma Palette.



Figure 2 - From top left to bottom right: original image (*Cave* by Stephen Bay Photography), AdaBins, MiDaS, DPT, GLPDepth, and 3D Scene Shape algorithms.

102



Figure 3 - From top left to bottom right: original image. (Trompe l'œil available at http://fr.pickture.com/blogs/pussycatdreams/1291713-TROMPE-L-OEIL#i), AdaBins, MiDaS, DPT, GLPDepth, and 3D Scene Shape algorithms.

8. CONCLUSION

We made a brief overview of existing state-of-the-art algorithms for monocular depth estimation and made a comparison between them using different images. In future work, we would like to investigate other novel approaches and their uses as well as hybrid implementations and combinations of existing ones, fine tunning for better depth predictions, segmentation, and 3D reconstruction from multiple images.

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104

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INFORMATION TECHNOLOGY SESSION

APPLICATION OF THE MS EXCEL ON NUMERICAL SOLVING OF ORDINARY DIFFERENTIAL EQUATIONS

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Abstract:

In classical physics, and especially in engineering, a large number of natural phenomena are described by ordinary differential equations. The majority of those differential equations do not have an analytical solution, which implies that In those situations, the solution must be sought numerically. That's when MS EXCEL can be applied.

In this paper, we will show and explain one method for the application of MS EXCEL on solving and creating graphical representations of their solutions.

Also, the obtained numerical solution of differential equations from MS EXCEL will be compared with their analytical solution.

Keywords:

Differential equations, MS EXCEL, Analytical solutions, Numerical solutions, Graphical representation.

INTRODUCTION

Many natural phenomena, the description of which deals with classical physics, result in mathematical terms, namely, algebraic and differential equations. These equations, primarily of a linear character, often have an analytical solution, while those equations that are of a non-linear character, usually do not have an analytical solution. For solving them, only numerical analysis that uses various types of successive algorithms remains available. The application of these algorithms is very complicated and requires special computer programs and applications.

The program package MS EXCEL is proven to be very effective for solving differential equations, although it has been noted that it is not so often used by engineers. However, the advantages of MS EXCEL are various, starting from availability to the wide range of users, and simplicity of its use but still software that can solve very complicated problems.

In this paper, based on the comparative analysis of the analytical and numerical solutions of the differential equation, we will present how MS EXCEL can be used in engineering practice for more effective solving of differential equations and for graphical representation of their solutions.

Correspondence:

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e-mail: tsekulicvts@gmail.com Comparative Analysis of Analytical and Numerical Solutions of Differential Equations

In the further course of this text, the analytical and numerical solution of the linear homogeneous differential equation of the first order with constant coefficients will be considered. This type of equation is easily solved analytically. It is clear that if the corresponding equation has an analytical solution, there is no need to look for a numerical solution. However, here, in addition to the analytical one, a numerical solution will be intentionally presented in order to perform a comparative analysis of the obtained results. Of vital importance here is the question of accuracy, that is, to determine to what extent the numerical solution deviates from the analytical one.

The mentioned differential equation has the following

form:

$$\frac{dy(x)}{dx} + ay(x) = 0; a \neq 0.$$

Equation 1 – Differential equation.

Along with this differential equation follows the initial condition:

 $y(x)\Big|_{x=x_0} = y(x_0) = y_0$ Equation 2 – Initial condition for the differential equation.

It is easy to show that the analytical solution of this differential equation, with the mentioned initial condition, corresponds to the following expression (explained in [1]):

$$y(x) = y_0 \cdot e^{-ax}$$

Equation 3 – Differential equation
used in this example.

Let us now take some concrete values for the above constants, for example:

$$x_0 = 0$$
 (2)

$$y_0 = 3$$
 (3)

Equation 4 – Values for the constants.

With the constants defined in this way (1), (2) and (3), expressions from Equation 1, Equation 2, and Equation 3 take the following form:

$$\frac{dy(x)}{dx} + 2y(x) = 0, \qquad (4)$$

$$y(x)\Big|_{x=x_0=0} = y(x_0) = y(0) = y_0 = 3$$
 (5)

$$y(x) = 3 \cdot e^{-2 \cdot x} \tag{6}$$

Equation 5 – The form of differential equation and initial condition.

Now it is necessary to draw a graph of the analytical solution given by (6). We will look for the values of the function y(x) in the following points:

$$x_0 = 0$$
 (7)

$$x_1 = x_0 + 1 \cdot \Delta \tag{8}$$

$$x_2 = x_0 + 2 \cdot \Delta \tag{9}$$

$$x_n = x_0 + n \cdot \Delta \tag{10}$$

Let's take it, for example: $\Delta = 0,1$ and =(0,1,2,...,40). The points $x_0, x_1, x_2, ..., x_n$ have the following values:

$$x_0 = 0$$
 (11)

$$x_1 = 0,1$$
 (12)

$$x_2 = 0,2$$
 (13)

$$x_{40} = 4$$
 (14)

Equation 7 – The observed points concerning the adopted values for
$$\Delta$$
 and n.

. . .

The values of the function y(x), given by (6) in selected points, (11), ..., (14), are as follows:

$$y_0 = y(x_0) = 3$$
 (15)

$$y_1 = y(x_1) = 2,456192$$
 (16)

$$y_2 = y(x_2) = 2,010960$$
 (17)

...
$$y_{n} = y(x_{40}) = 0,001006$$
 (18)

Equation 8 - The values of the function y(x) for selected points.

All previously presented data are shown in Table 1, and the graph of function y(x) is presented in Figure 1.

Let us now look for the numerical solution of this problem given by (4) and (5).

The first derivative of the function y(x) can be approximated by the following expression, obtained from [2]:

$$\frac{dy(x)}{dx} \approx \frac{y_{n+1}^* - y_n^*}{\Delta}$$

Equation 9 – Approximation of the function y(x).

Substituting the previous expression (Equation 9) into (4), and taking into account that the function y(x) itself now takes its values at selected points of the independent variable (*x*), it will follow:

$$\frac{y_{n+1}^* - y_n^*}{\Delta} + 2 \cdot y_n^* = 0 \tag{19}$$

$$y_{n+1}^* - y_n^* + 2 \cdot \Delta \cdot y_n^* = 0$$
 (20)

$$y_{n+1}^* - (1 - 2 \cdot \Delta) \cdot y_n^* = 0$$
 (21)

$$y_{n+1}^* = \left(1 - 2 \cdot \Delta\right) \cdot y_n^* \tag{22}$$

Equation 10 – Algorithm for the numerical solution of the differential equation.

Now we should use the algorithm derived above and calculate the approximate (approximated) values of the function $y^*(x)$ at the selected points (11), ..., (14).. These values are:

$$y_0^* = 3$$
 (23)

$$y_1^* = (1 - 2 \cdot \Delta) \cdot y_0^* = (1 - 2 \cdot 0, 1) \cdot 3 = 2, 4$$
 (24)

$$y_{2}^{*} = (1 - 2 \cdot \Delta) \cdot y_{1}^{*} = (1 - 2 \cdot 0, 1) \cdot 2, 4 = 1,92$$
 (25)
...

$$y_{40}^* = (1 - 2 \cdot \Delta) \cdot y_{39}^* = (1 - 2 \cdot 0, 1) \cdot 0,000498 = 0,000399$$
 (26)

Equation 11 - The approximate (approximated) values of the function $y^*(x)$ at the selected points.

As last time, all previously presented data are shown in Table 1, and the graph of the function $y^*(x)$ is shown in Figure 1. Finally, it should be said that in each step the difference between the exact analytical and approximate numerical solution was calculated, using the following expression:

$$\Delta^* = y(x) - y^*(x)$$

Equation 12 - The difference between the exact analytical and approximate numerical solution.

Table 1- Analytical and numerical solution of differential equation with the initial condition, Equation 5.

<i>(x)</i>	y(x)	$y^*(x)$	Δ^{\star}
0	3	3	0
0,1	2,456192	2,4	0,056192
0,2	2,01096	1,92	0,09096
0,3	1,646435	1,536	0,110435
0,4	1,347987	1,2288	0,119187
0,5	1,103638	0,98304	0,120598
0,6	0,903583	0,786432	0,117151
0,7	0,739791	0,629146	0,110645
0,8	0,60569	0,503316	0,102373
0,9	0,495897	0,402653	0,093243
1	0.406006	0.322123	0.083883
1,1	0,332409	0,257698	0,074711
1,2	0,272154	0,206158	0,065995
1,3	0,222821	0,164927	0,057894
1,4	0,18243	0,131941	0,050489
1,5	0,149361	0,105553	0,043808
1,6	0,122287	0,084442	0,037844
1,7	0,10012	0,067554	0,032566
1,8	0,081971	0,054043	0,027928
1.9	0,067112	0,043235	0,023878
2	0,054947	0,034588	0,020359
2,1	0,044987	0,02767	0,017317
2,2	0,036832	0,022136	0,014696
2,3	0,030156	0,017709	0,012447
2,4	0,024689	0,014167	0,010522
2,5	0,020214	0,011334	0,00888
2,6	0,01655	0,009067	0,007483
2,7	0,01355	0,007254	0,006296
2,8	0,011094	0,005803	0,005291
2,9	0,009083	0,004642	0,00444
3	0,007436	0,003714	0,003722
3,1	0,006088	0,002971	0,003117
3,2	0,004985	0,002377	0,002608
3,3	0,004081	0,001901	0,00218
3,4	0,003341	0,001521	0,00182
3,5	0,002736	0,001217	0,001519
3,6	0,00224	0,000974	0,001266
3,7	0,001834	0,000779	0,001055
3,8	0,001501	0,000623	0,000878
3.9	0,001229	0,000498	0,000731
4	0,001006	0,000399	0,000608







Figure 2 – Presentation of the solution of the differential equation using the MS EXCEL package.

All the obtained results, in this case, could be done by direct calculating, without using some additional software help. Nevertheless, taking into consideration that in engineering practice, there are problems described with very complicated differential equations, we wanted to present how MS EXCEL can be used for solving these kinds of problems.

All the necessary calculations, tabulation of data, and drawing of function graphs were done with the help of the MS EXCEL program package. In this simple example, we can see that with the help of this program package, it is possible to perform various types of mathematical analysis very efficiently, easily, and comfortably, using functions and other features of MS EXCEL, Figure 2.

The great advantage of this package is that it is relatively cheap compared to competing packages and that it is available to a wide range of users.

3. DISCUSSION OF THE OBTAINED RESULTS AND FURTHER APPLICATION

In this chapter, two processes from technical practice will be briefly described, one is from the field of Fluid mechanics, while the other is from the field of Heat and mass exchange. Both processes are described by systems of differential equations and their solutions are sought with the help of numerical analysis. The complete processing of the results was carried out in the MS EXCEL program package. The first process considers the flow of a suspension (a two-phase mixture of solid and liquid phases) moving between two axial cylinders. The mathematical model of suspension flow describes the velocity field of the mixture as a whole (v) and the micro rotation velocity field of the solid phase within the mixture (ω), depending on the radial coordinate (r). This model is defined by a system of two ordinary linear differential equations of the second order with variable coefficients. An analytical solution to this problem is presented in reference [3], but it is extremely complicated and is given in the form of special functions. In order to confirm the accuracy of the analytical solution, a numerical solution was developed, which is presented in reference [4]. The comparative analysis of the analytical and numerical solution showed an extremely good agreement of the results (there is a negligibly small difference).

The second process considers the exchange of heat and mass between the drying agent - unsaturated moist air and moist materials of natural products. Namely, warm unsaturated moist air transfers heat to moist material, at the expense of which the moisture in it evaporates. In [5], the issue of drying natural materials in large industrial plants - belt dryers - was considered. Drying of a thick layer of wet material on a conveyor belt is described by a system of nonlinear partial differential equations [5], while a simplified variant of this problem - drying of a thin layer of wet material on a conveyor belt is described by a system of nonlinear ordinary differential equations [6]. The results of the numerical solution of these equations were compared with the results of measurements on a real process. The agreement of the results is quite good with a present error that is within the expected value.

Both problems, mentioned above, have very demanding solving procedures. In our practice, MS EXCEL was of great help, considering the ease of use and availability to students and engineers [7].

4. CONCLUSION

Based on the example of obtaining analytical and numerical solutions of differential equations, we have presented how can MS EXCEL program package be applied to solving this kind of problem, and how can it be used for graphical representation and analysis of the solutions.

Also, two examples were given that present real technical processes. These processes are described by complex mathematical models that require the application of numerical analysis. Application of some specialized software packages for this purpose in these cases gave almost no results. Unlike them, the MS EXCEL program package served the purpose perfectly and solved the mentioned problems very efficiently.

Interestingly, engineers do not use this package very often in practice, that is, they rarely use it for numerical analysis. Based on our experience, MS EXCEL should be used more in engineering practice, considering all its features.

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INFORMATION TECHNOLOGY SESSION

POLITICAL COMMUNICATION IN SERBIA – DIGITAL VERSUS TRADITIONAL MEDIA

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Abstract:

Politics-related communication is exceptionally significant as the messages sent to the electorate have a decisive influence on the formation of their stances on political matters and figures, electoral participation, and, thus, elections outcome. The present study aims to provide insight into contemporary digital political communication in Serbia by exploring voter preferences regarding obtaining political information through television and print media as well as official websites and social networks owned by broadcasters. The majority of existing academic papers belonging to the field of digital political communication emphasise the importance of modern technologies for shaping voters' attitudes and structuring political campaigns, assuming, as a fact, the willingness of citizens to obtain information primarily through the digital sphere. We have recognised the importance of investigating the significantly under-researched process of shifting citizens' attention from traditional to digital media. Thus, we set up a research hypothesis stating that contemporary political communication should be executed mainly digitally. Our hypothesis was evaluated by means of an exploratory study based on a series of questions related to respondents' habits regarding political information acquisition through all relevant traditional or modern media operating in Serbia. The raw data were coded to be imported to SPSS and quantitatively analysed using descriptive statistic measures, i.e., minimum, maximum, mean, standard error and standard deviation. The subsequent qualitative analysis convinced the authors that the hypothesis should be accepted since the respondents undoubtedly prefer to obtain political knowledge via the Internet, although still inclined to be informed through traditional media.

Keywords:

Political Communication, Political Marketing, Digital Platforms, Traditional Media, Digital Media.

INTRODUCTION

One of the hallmarks of modern politics is the ruthless and unethical information warfare that is constantly waged between political competitors sharing the common goal of obtaining popular support and rising to power. The battlefield of political competition has shifted from parliament and political assemblies to traditional mass media and digital media, skyrocketing electoral interest and participation. Traditional broadcasting methods, such as radio and television, had a predominantly informative role, while the new internet-powered media is mainly politically controlled, persuasive, and aimed at influencing the outcome of elections by shaping public opinion.

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Research conducted by Cohen, Tsfati and Sheafer on a sample of 56 members of The Knesset, the Israeli House of Representatives, showed that politicians of all affiliations recognise the importance and the power of the media and, therefore, adjust their public behaviour to attract maximum media attention. [1] Models explaining the influence of media on voters can be divided into two categories, depending on whether they assume that the broadcasters strive to provide factual information to predominantly rational individuals or aim to engage in propaganda by manipulating voters and exploiting their cognitive deficits. [2]

Freedom of speech, guaranteed and protected by the highest legislative acts of modern democratic societies, bestows media with an inexhaustible and almost unlimited power that grants them a dominant position over political subjects. The author Salh noticed that nowadays, broadcasters are capable of altering the information on current affairs partially or even wholly before its distribution to the electorate and argued that the ascend of media into a position of strength debilitated the political entities, placing them in a position of unprecedented weakness. [3] At the same time, the public's eagerness for online interaction and information sharing has caused a significant problem related to media consumption - the phenomenon commonly known as information overload and scientifically described as a situation in which the amount of available information surpasses the individuals' cognitive capacity to process it. [4] The complexity and multilayeredness of political interactions have inspired numerous authors to examine the distinctive characteristics of traditional and contemporary media in the political context.

The present paper comprises six sequential sections (seven, counting the introduction) to visualise the theoretical framework and the exploratory research executed by the researchers. The first three sections constitute the literature review: the first section is about the definition of political communication in the digital sphere, the second deals with the characteristics of digital political communication, and the third evaluates the credibility of digital media. Subsequently, the fourth section refers to the methodology, whereas the fifth section includes the tabular presentation and discussion of the research results, finalising the paper with the conclusion, which is displayed in the sixth section.

2. POLITICAL COMMUNICATION IN THE DIGITAL SPHERE

Having studied the new political strategies applied in Serbia, the authors Jevtovic and Cebalovic argued that the rise of novel communication forms based on digital technologies has led to the division of the media system into two elementary groups, the traditional and the new. This trend simultaneously caused their restructuring and operational revamp, especially in terms of information processing and PR. [5]

Traditional media in all its forms (press, radio, and television) refers to communication from one source of information to numerous recipients. [6] They are much less user-oriented than new media, which, based on the multimedia nature of the content, provide an intensive, informative, and much more enjoyable user experience. The primary technological reasons for voters' preference for new media lie in the accessibility and open architecture of the Internet. In contrast, the socio-political reasons lie predominantly in the opportunity to obtain political information, exchange opinions and ideas publicly, overcome language and cultural barriers, connect with like-minded people, and receive feedback from politicians and political organisations. Communication in the digital sphere, through computers and cell phones with Internet access, combines all the advantages of traditional media in addition to the peculiarity that all actors can assume the role of creator and transmitter of information [7], creating a new order where power is primarily reflected in the possession of information. [8]

The most common argument explaining the negative sides of digital communication refers to the public nature of the Internet [9], a feature that allows broad access to criticism, negative feedback, disinformation and even lies, thereby encouraging misunderstandings as cybernauts are often unable to distinguish valid information from malicious propaganda. The disadvantages of online communication explained above present political parties with the challenge of making their content stand out from the abundance of positive and negative information available, attracting the target audience's attention, and establishing communication that secures consistent trust confirmed in voters' electoral behaviour.

Informing citizens and influencing their attitudes are the ultimate goals of all political communication activities by political parties, interest groups, or the media. [10] Authors such as Jevtovic and Cebalovic noted that in today's circumstances, the events are less important than the publicity they achieve and the impression they leave on public opinion. [5] The overload of voters that possess a wide variety of information and the possibility of employing viral campaigns based on the spread of negative and often untrue news are two main factors that political subjects must keep in mind when making decisions about the choice of communication channels and strategies.

3. CHARACTERISTICS OF POLITICAL COMMUNICATION IN THE DIGITAL SPHERE

Political news still occupies a central place in traditional media. Still, political communication is increasingly shifting to new, hybrid media systems in an environment characterised not only by reduced citizen attention but also by networked and polarised political information flows and the rise of undemocratic movements and parties. [11] Political communication in the digital sphere has taken on a specific tone, considered much more dynamic, aggressive, and competitive than the one used in traditional media coverage. The reason for this is the striving of all political rivals to become maximally exposed in the situation of total information overwhelm. The research conducted by Kruse, Norris and Flichum has confirmed the assumption that the Internet's anonymity potential reduces the likelihood of civil discussion and creates additional barriers, which are inexistent in face-to-face communication. [12]

The characteristics of political communication identified by international authors are also reflected in political communication in Serbia. The research conducted by Jevtovic and Cebalovic showed that Serbian citizens do not recognise the importance of political programs and that they focus their online political communications on commenting on campaigns and party leaders, cultivating an aggressive and intolerant attitude towards dissenters. These authors also determined that representatives of the authorities in Serbia still prefer traditional forms of communication with journalists and the target audience. In contrast, the opposition prefers modern methods of communication based on social networks. [5]

4. THE CREDIBILITY OF DIGITAL MEDIA

A 2016 survey of respondents from the digitally literate generation in Croatia found that they perceive political propaganda most frequently on the Internet and least frequently via radio broadcasts. [13] This finding can be explained by the ever-increasing use of devices with Internet access for interpersonal and business communication. Most well-established media companies have recognised the constant and steady increase in digital-based information consumption and, therefore, transferred a specific part of their activities to the Internet, to specialised portals and official profiles on social networks. New informative media, which are non-existent in the offline sphere and pursue a more open editorial policy due to the anonymity of content authors and the often utterly opaque ownership structure, represent competition for traditional media on the Internet.

Within the scope of a paper dealing with online media and perceptions of source credibility in a political context, Flanagin and Metzger argue that source information is crucial to credibility, pointing out the prevailing scientific view that digital media sometimes lack traditional authority indicators such as author identity and established reputation. [14] The legal systems of many countries, especially those lagging behind in technological development, have yet to recognise the necessity of establishing a legal framework geared toward online media. Their failure to do so opens space for forming partisan platforms that intentionally manipulate facts and spread misinformation or even outright lies, aiming to fulfil precarious political agendas.

Radovic and Dojcinovic noted that Serbian society also faces the surge of predatory platforms that spread misinformation and clickbait news and pointed out that specialised websites dedicated to verifying the truthfulness of information are increasingly counterbalancing the sensationalist online media. [15]

Since the current research foundation, based on small samples of the electorate in Serbia and other ex-Yugoslav countries, mainly explores the impact of digital communication channels on voter awareness and political activity, the present study aims to go a step further. The objective is to find out how Serbian citizens view the process of media transition to the digital sphere, i.e., receive insight into their willingness to receive information through traditional media in digital form.

5. METHODOLOGY

The conducted exploratory research relied on the survey method. A questionnaire was designed using the Google Forms platform, which was electronically distributed to the respondents. The sample was prompted to provide their demographic information and answer a series of questions related to their habits regarding obtaining political information from print and television media, as well as from social networks and websites operated by traditional media. A 5-point Likert scale was used to assess the respondents' habits. Each question in the questionnaire was marked as mandatory. Hence, all 117 questionnaires were completely filled out.

Data collection lasted from August 29 to September 11, 2022. The sample consists of 117 respondents, selected according to the principle of convenient sampling. The main criterion was being entitled to vote in elections organised in the Republic of Serbia, which means that only adult citizens (18 years and older) were considered. The primary survey data was used to achieve insight into the sample's demographics. The demographic analysis revealed that both genders are similarly represented, with a slightly larger proportion of females (53.8%). Most respondents belong to the working-age population (35.9% aged 36-45, 20.5% aged 46-55, and 9.4% aged 56-65). In contrast, the proportion of students and older adults was significantly lower than that of working-age individuals. The majority (73.5%) indicated Belgrade as their residence, whereas 26.5% live in suburban Serbian cities and settlements. Subsequently, the consumption of an extensive selection of relevant daily and weekly newspapers and television stations, as well as their digital versions was assessed. The response options "very often", "often", "occasionally", "rarely", and "never" were utilised. Numerical values were allocated to all response options (1 = very often, 2 = often, 3 = occasionally, 4 = rarely, 5= never) to facilitate an exhaustive statistical analysis of the data collected through the survey. Since respondents' data could not be explained solely on the basis of the raw data collected, data coding was necessary to explore statistical regularities and anomalies. IBM's SPSS (Statistical Package for the Social Sciences) was utilised for data analysis and management.

6. RESULTS AND DISCUSSION

A comparison of the arithmetic means showed that the most popular televisions in the classic form in descending order are RTS, Happy, and Pink, which is a somewhat logical result that can be explained by the fact that all three channels have national coverage and that a large part of their program is political reporting. However, the order of popularity is entirely different regarding information via the Internet: the respondents put the website and social networks owned by N1 television in the first place, while the digital channels owned by B92 and RTS televisions came in second and third place. It can be assumed that the outcome of N1 television being more prevalent in the digital sphere than in the traditional media environment is a result of the fact that it is the opposition medium that offers voters a different and exciting look at the political situation in Serbia. Still, it does not have a national frequency and is not included in the portfolios of the most represented cable operators.

In most cases, television media are consumed in traditional form rather than via the Internet, except for the least popular TV channel Nova S. The fact that the news published by Nova S was predominantly accessed via the Internet can also, as in the case of N1, be explained by the weak coverage, i.e., the lack of national frequency, as well as by the fact that it is an opposition medium whose Internet platforms are constantly updated with exclusive information unavailable to other media.

Comparing the averages of the arithmetic means by survey options allowed to determine the overall popularity of the media companies. It turned out that the respondents preferred to be primarily informed through the televisions N1, B92, and RTS (counting both traditional and digital forms).

Quantitative analysis showed that the three most read newspapers in print form in descending order are Politika, Blic, and Kurir. The daily newspaper Politika occupying the first place might be explained by its long tradition and reputation, which has existed since 1904. The popularity of Blic and Kurir newspapers is attributed to their low cost, high circulation, and mass distribution.

In contrast to television, newspapers are generally followed more closely on the Internet than in print. Interestingly, the three previously mentioned media are also the most popular in terms of information in the digital sphere. However, the order is somewhat different. Blic is in first place, Kurir in second, and Politika in third. This result might be explained by the fact that these are popular and well-established media that have invested heavily in creating responsive, hourly updated websites.

The survey also showed that respondents do not have a pronounced habit of reading weekly newspapers, which can be explained by their high cost and the fact that they offer only abridged versions of texts for free on the Internet.

	Descriptive Statistics						
	Ν	Min	Max	М	SE	SD	
RTS (tv)	117	1	5	2,98	0,111	1,196	
RTS (net)	117	1	5	3,60	0,109	1,175	
Pink (tv)	117	1	5	3,15	0,107	1,154	
Pink (net)	117	1	5	3,73	0,108	1,172	
B92 (tv)	117	1	5	3,19	0,087	0,937	
B92 (net)	117	1	5	3,38	0,109	1,181	
Happy (tv)	117	1	5	3,09	0,109	1,179	
Happy (net)	117	1	5	3,65	0,118	1,275	
Prva (tv)	117	1	5	3,52	0,085	0,925	
Prva (net)	117	1	5	3,94	0,097	1,053	
N1 (tv)	117	1	5	3,26	0,109	1,177	
N1 (net)	117	1	5	2,80	0,113	1,226	
Nova S (tv)	117	1	5	3,88	0,096	1,044	
Nova S (net)	117	1	5	3,69	0,102	1,102	

Table 1 - Statistical indicators related to the frequency of obtaining information through television and digital platforms owned by television media.

N=number of subjects, Min=minimum, Max=maximum, M=mean, SE= standard error, SD= standard deviation

 Table 2 - Statistical indicators related to the frequency of obtaining information via print media and digital platforms owned by print media.

		Descrip	tive Statistics			
	Ν	Min	Max	М	SE	SD
Politika (print)	117	1	5	3,47	0,114	1,229
Politika (net)	117	1	5	2,48	0,114	1,236
Kurir (print)	117	1	5	3,68	0,088	0,954
Kurir (net)	117	1	5	2,10	0,114	1,234
Blic (print)	117	1	5	3,54	0,098	1,055
Blic (net)	117	1	5	1,87	0,106	1,141
Alo (print)	117	1	5	3,83	0,089	0,967
Alo (net)	117	1	5	2,73	0,121	1,304
Informer (print)	117	1	5	3,84	0,093	1,008
Informer (net)	117	1	5	3,11	0,122	1,318
Danas (print)	117	1	5	4,13	0,084	0,905
Danas (net)	117	1	5	3,55	0,114	1,235
Srpski telegraf (print)	117	1	5	3,84	0,092	0,991
Srpski telegraf (net)	117	1	5	3,59	0,115	1,240
Objektiv (print)	117	1	5	4,03	0,087	0,946
Objektiv (net)	117	1	5	3,71	0,11	1,189
NIN (print)	117	1	5	4,00	0,11	1,189
NIN (net)	117	1	5	3,90	0,107	1,155
Vreme (print)	117	1	5	4,17	0,096	1,036
Vreme (net)	117	1	5	3,97	0,100	1,082
Nedeljnik (print)	117	1	5	4,04	0,104	1,125
Nedeljnik (net)	117	1	5	3,91	0,101	1,095
Tabloid (print)	117	1	5	4,32	0,081	0,877
Tabloid (net)	117	1	5	3,69	0,127	1,374

N=number of subjects, Min=minimum, Max=maximum, M=mean, SE= standard error, SD= standard deviation

7. CONCLUSION

The survey results indicate that respondents have conflicting views about traditional and digital media. The sample generally prefers to read print media digitally, on websites or social networks. However, when it comes to television programs, they prefer watching them in a traditional format rather than online. To reach a conclusion about the hypothesis's confirmation or rejection, the arithmetic means values for the responses related to traditional media and their Internet versions were compared. Since the values of the arithmetic means differed less in the case of television than in the case of print media, it was decided to accept the hypothesis. The decision to accept the hypothesis is in accordance with official statistical indicators, showing a constant growth in the number of Internet users among the citizens of the Republic of Serbia and recording their increasingly frequent presence on social networks.

Lastly, we can conclude that voters in the Republic of Serbia undoubtedly follow social networks and content published by political subjects through their Internet communication channels. Considering the growing popularity of the digital communication sphere, there is no doubt that favourable future election results can only be achieved by those political subjects who recognise the importance of political marketing on the Internet and develop a suitable strategy for communicating with the electorate.

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INFORMATION TECHNOLOGY SESSION

FUNCTOR AND APPLICATIVE FUNCTOR USAGE IN TYPESCRIPT

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Abstract:

Leveraging functional programming concepts to make front-end application development faster and easier, with fewer bugs has been tried with pure functional programming languages such as Elm. Visible improvement in development time and application quality compared to JavaScript has been recorded. TypeScript is a multi-paradigm programming language, so it is possible to implement these concepts without switching languages. Functors and applicative functors are some of the key concepts of functional programming, useful for processing complex objects and collections of data. As TypeScript is often used to visualize lists of data retrieved from a server, functors and applicative functors could be used to process data into a format required for visualization. This paper presents theoretical explanations of the Functor and Applicative Functor concepts in category theory and provides their implementations in TypeScript, focusing on Maybe and List functors. The use cases were then shown, which demonstrate that they could be useful, especially when abstracting complex concepts, so they could be used and invoked on demand, usually with a simple command.

Keywords:

Functional Programming, Functor, Applicative Functor, TypeScript.

INTRODUCTION

Web applications today are used for a number of purposes in every walk of life. One of the largest industries in the IT sector is web programming with 24.5 million people employed and millions of apps deployed annually [1]. With such work volume, it would be convenient to develop tools and technologies that could aid in lessening the amount of time spent in writing code, error correction, testing and validation, and synchronizing ideas between developers working on projects. Concepts of functional programming [2] are highly suitable for solving these problems [3]. The nature of functional programming languages aids in developing highly abstract and declarative code, that is readable and concise. This allows programmers to write and review code faster as declarative code maps better to a programmer's thinking process [3]. Also, since the functional paradigm is based on rigorous mathematical concepts [4], [5], code validation is easier [2]. Another useful feature of functional programming are pure functions which make testing much easier and facilitate code parallelization [3].

TypeScript is a multi-paradigm programming language that adds static typing to JavaScript. In Type-Script, functions are first-class objects, and generic typing is supported, which enables an easy implementation of concepts of functional programming.

This paper will focus on the most common functional programming concepts, functors and applicative functors, how they can be implemented in a multi-paradigm environment of TypeScript, and how they can be leveraged and used in front-end development. The paper is structured in the following way. First, the mathematical background of functors is presented and their implementation in TypeScript. Then, a similar structure is used for discussing applicative functors. Finally, the concluding section discusses if TypeScript achieved the desired improvements and compare them to a scenario where they aren't used.

2. FUNCTORS

After categories, functors are the most important concept of category theory [5]. They are particularly useful when dealing with complex objects or collections of data. Due to the importance of functors, concepts based on them are implemented in many procedural programming languages such as Python, Java, JavaScript, etc.

2.1. FUNCTORS IN CATEGORY THEORY

In category theory, functors are a mapping between two categories [6]. Given two categories, C and D, functor F is a mapping such that:

- associates every object a in *C* to an object *Fa* in *D*, and
- associates each morphism f: $x \rightarrow y$ in C to a morphism *Ff*: $Fx \rightarrow Fy$ in D.

These mappings of morphisms must be such that the following two conditions hold:

- It maps identity morphisms in *C* to identity morphisms in *D*. For each object *X* in *C* it must hold that $Fid_x = id_{Fx^2}$ and
- Mapping of composition of any two morphisms gand h, such that $h: a \rightarrow b$ and $g: b \rightarrow c$, must be equal to composition of mappings of those morphisms, or formally: $F(g \circ h) = Fg \circ Fh$.

If these two conditions are met, the functor preserves the structure of the original category. If a category is pictured as a web where the objects are considered as nodes, and morphisms between them as edges, then functors aren't allowed to introduce tears to the web's fabric [5]. They can merge multiple objects or morphisms together, but they cannot remove any connections. If a path exists between some two objects in the original category, then a path must also exist between their mappings in the resulting category. Categories consist of objects and morphisms, i.e. connections between objects. If these concepts are transferred to programming, then objects would be data types and morphisms would correspond to functions, which map one data type to another [5]. If these categories are pictured as objects, in a category of categories, then functors would be morphisms between categories. Considering that categories in programming correspond to types, functors in programming would then be type constructors. In other words, functors in programming are a type of containers or wrappers on basic data types, that add certain semantics to them, and they would also add functionality according to that semantics to the functions they map and the underlying data types that they wrap [2].

2.2. FUNCTORS IN TYPESCRIPT

A functor implementation¹ needs to implement one function called the map function. This function receives a functor and a function, then applies that function to a value contained inside the functor. Function map receives a function (that receives a value of type a, and returns a value of type b), and a value of type a wrapped inside functor f. It returns a value of type b, also wrapped within f. From the function type, it can be concluded that the map function receives a functor and a function and applies that function to the value wrapped inside the given functor, according to the context of the functor within which it is wrapped [2]. If currying [7] is applied, the function type can be written as in Listing 1.

class Functor f where fmap :: (a -> b) -> (f a -> f b)

> Listing 1 - map function type rewritten so it accepts one parameter (a function) and returns one parameter (also a function)

1 All the code implementations in this paper, and more, can be found at our GitHub page

Function map can also be seen as a function that takes a function of type $a \rightarrow b$, and returns a function of type $Fa \rightarrow Fb$. If compared to the mathematical definition of a functor, it can be derived that the definitions are equivalent. The map function, thus, maps objects and morphisms in one category, to objects and morphisms in another category. To be a functor, *f* has to satisfy the two conditions specified above. TypeScript considers functions first-class objects, and supports type variables and generic types, features to be used extensively for functor construction in TypeScript.

2.2.1. Maybe functor

One of the most commonly used functors in functional programming is the Maybe functor. The Maybe functor gives the value a context of "uncertainty". The value may or may not be contained within the functor. This is commonly used for computations that may or may not return a value (like finding an element within a list, or an entry in a database), or for computations that may break due to an error. There are two forms that the Maybe functor can take: Nothing, which represents the absence of the value contained within the functor, and Just val, which represents that a value is present inside. The two options are two separate type constructors, so the Maybe functor has two functions that return different forms of the Maybe functor. In addition to this, value a represents a type parameter which is used to declare which type the Maybe functor will wrap. Mapping of a function (Listing 2) on a Nothing value produces no result, as there is nothing to map the function to. Mapping of a function to Just val applies that function to val, the value contained inside the functor, i.e., passes on the function to the value inside the functor. The map function satisfies both functoriality conditions [5]. As mentioned, Maybe is made from two constructors, and it receives one type parameter. If this is translated into TypeScript, that would mean that there are two types necessary, each with its own constructor. This is best implemented if Maybe is a generic abstract class that takes a type parameter and is inherited by Just and Nothing types (Listing 2). The Maybe class could also have an abstract map method that can be used for polymorphism.

The Maybe functor is particularly useful when chaining multiple operations that may fail, or for element lookup in lists, which may fail (Listing 3).

```
abstract class Maybe<T> {
    abstract mmap<X>(f: (x: T) => X): Maybe<X>
}
class Just<T> extends Maybe<T> {
    value: T;
    constructor(value: T) {
        super();
        this.value = value;
    }
    mmap<X>(f: (x: T) => X) {
        return new Just<X>(f(this.value));
    }
}
class Nothing<T> extends Maybe<T> {
    mmap<X>(f: (x: T) => X) {
        return new Nothing<X>();
    }
}
function maybeMap<T, U>(f: (x: T) => U, m: Maybe<T>): Maybe<U> {
    f = curry(f);
    if (m instanceof Just) {
        let {value} = m;
        return new Just(f(value));
    }
    return new Nothing<U>();
}
```

118

Listing 2 - Example implementation of Maybe functor in TypeScript.

```
function listLookup(list: Array<number>, x: number): Maybe<number> {
    for (let i = 0; i < list.length; i++) {</pre>
        if (list[i] == x)
             return new Just(i);
    return new Nothing<number>;
}
function inc(x: number): number {
    return x + 1;
}
let list1 = [1, 2, 3, 4, 5];
let lookupResult1 = listLookup(list1, 3).mmap(inc).mmap(inc);
let lookupResult2 = listLookup(list1, 6).mmap(inc).mmap(inc);
console.log(lookupResult1); // Prints Just: { "value": 4 }
console.log(lookupResult2); // Prints Nothing: { }
// More functional programming way
lookupResult1 = maybeMap(inc, maybeMap(inc, listLookup(list1, 3)));
lookupResult2 = maybeMap(inc, maybeMap(inc, listLookup(list1, 6)));
console.log(lookupResult1) // Prints Just: { "value": 4 }
console.log(lookupResult2) // Prints Nothing: { }
```

Listing 3 - Example of Maybe usage in TypeScript.

2.2.2. List functor

When constructing a list, in most programming languages, it is necessary to pass the type of elements it will contain. This is similar to previously mentioned type constructors, which receive a type as their parameter. Also, a list adds a new context to a type, a context of non-determinism [5], since a list isn't a single value, but a collection of multiple values. Thus, if a map function that satisfies both functoriality conditions can be constructed, List can also be considered a functor. Such a function can indeed be constructed, and List is indeed a functor. Both lists, and map function for lists are already implemented in TypeScript, but the List type, however, isn't a recursive type as it is in functional programming. Therefore, we replicated recursive definition in TypeScript (Listing 4). Map function (Listing 5) can be easily implemented similar to how it was implemented in Haskell [2]. This function receives a list and a function, then applies that function to each element in the list. This makes sense from a mathematical perspective - a list is a collection of values, where each one has an equal probability of being accessed or modified. Because of that, there is no specific subset of elements, but the function is applied to each element.

```
abstract class List<T> {
}
class Empty<T> extends List<T> {
}
class Cons<T> extends List<T> {
    head: T;
    tail: List<T>;
    constructor(value: T, tail: List<T>) {
        super();
        this.head = value;
        this.tail = tail;
    }
}
```

Listing 4 - List type definition in TypeScript.

```
let l = new Cons(5, new Cons(4, new Cons(3, new Cons(2, new Cons(1,
Empty<number>)))))
function listMap<T, U>(f: (x: T) => U, l: List<T>): List<U> {
    if (l instanceof Cons) {
        var {head, tail} = 1;
        return new Cons(f(head), listMap(f, tail));
    }
    return new Empty<U>();
}
let listMapResult = listMap(inc, 1);
console.log(listMapResult) // Prints List: {"head": 6, "tail": {"head": 5, "tail":
    {"head": 4, "tail": {"head": 3, "tail": {"head": 2, "tail": {}}}}
```

Listing 5 - List map function implementation in TypeScript and sample usage.

3. APPLICATIVE FUNCTORS

Functors are useful when applying a function to an element contained within some wrapper when those functions have only one input argument. To enable function with multiple input arguments, one has to deal with currying and partial application. Currying isn't native to TypeScript as it is to pure functional programming languages, so it needs to be implemented. Still, the currying in TypeScript is easy to implement, and can be particularly useful when partial application is used, especially for concepts from category theory such as applicative functors. It was already discussed that a functor is a sort of wrapper that adds context to a value. It is possible to pass a function to this wrapper, that is, it is possible to enclose a function within a functor. If the function takes multiple parameters, it is also possible to map a function to a value within a functor, and thus receive a partially applied function in a wrapper. Eventually, it will be required to pass the second parameter to the function, so that a result can be evaluated. Let the other value be wrapped in a functor as well. A function that will achieve this has to have a signature $f(a \rightarrow b) \rightarrow fa \rightarrow fb$. The reason why this function returns a value in a functor is that, if the initial function takes more than two parameters, multiple partial applications will need to be performed. If the function has the signature $f(a \rightarrow b) \rightarrow fa \rightarrow fb$, then this partial application can be chained and performed easily [8].

Invocation of a partially applied function in a functor and chaining described in the previous section can be achieved using a special concept called applicative functors. Applicative functors need to fulfill two main functionalities [9]. The first is to implement a function with a signature described above, which is usually called "supermap", and represented with an infix "<*>" operator. The second functionality is to put a value within a wrapper or to add a certain context to it. In other words, it should be able to put a value inside a functor. This can be described with a typeclass definition shown in Listing 6.

<pre>class (Functor f) => Applicative f where</pre>
pure :: a -> f a
(<*>) :: f (a -> b) -> f a -> f b

Listing 6 - Applicative typeclass definition.

Type of the pure function somewhat describes its function. It takes a value of type a, and encapsulates it into functor f, producing f a. On the other hand, the "<*>" operator type is similar to map function type, but instead of a -> b, it takes f (a -> b). That's why, in this paper, this function will be designated as a "supermap"

There are a couple of conditions that constructs need to satisfy in order to be considered applicative functors. Those conditions are [8]:

- 1. Identity: pure id $\langle * \rangle$ v = v;
- 2. Composition: pure (.) <*> u <*> v <*> w = u <*> (v <*> w);
- 3. Homomorphism: pure f <*> pure x =
 pure (f x);
- Interchange: pure f <*> pure x = pure (f x), and
- pure f <*> x = fmap f x, especially important for mapping functions that receive multiple parameters.

3.1. APPLICATIVE FUNCTORS IN TYPESCRIPT

Implementation of applicative functors isn't much more difficult than their implementation in, for example, Elm [10]. In addition, because of the inability of TypeScript to statically infer the return data types in currying, the code TypeScript interpreter will throw warnings about type mismatch. Still, the code will work and produce the desired outputs.

3.1.1. Maybe applicative functor

The supermap function (Listing 7) returns Nothing if the passed value that a function is being mapped to is also Nothing. Otherwise, the function is taken out of the wrapper, and applied to the value inside the Just wrapper. For a value x, the pure function (Listing 7) returns Just x, because that is the minimal context that keeps the information about the original value [2]. One important thing to remember is, since applicative functors are largely used together with partial application, the function passed as a parameter must be curried. So, it will be necessary to modify the map function by adding the function currying.

One of the main benefits of applicative functors is applying a function of multiple parameters to values in a wrapper (Listing 8).

```
function maybeMap<T, U>(f: (x: T) => U, m: Maybe<T>): Maybe<U> {
    f = curry(f); // IMPORTANT: this line is added compared to the implementation in
Listing 8
   if (m instanceof Just) {
        var {value} = m;
        return new Just(f(value));
    }
   return new Nothing<U>();
}
function maybePure<T>(x: T): Maybe<T> {
   return new Just(x);
}
function maybeSuperMap<T, U>(f: Maybe<(x: T) => U>, m: Maybe<T>): Maybe<U> {
   if (f instanceof Just) {
        var {value: func} = f;
        return maybeMap(func, m);
    ì
   return new Nothing<U>();
}
```

Listing 7 - Implementation of pure and supermap functions for Maybe and modified map function in TypeScript.

```
function threeNumbers(a: number, b: number, c: number): number {
    return a * b + c**2;
}
let n1 = new Just(3);
let n2 = new Just(4);
let n3 = new Just(2);
let supermap1 = maybeSuperMap(maybePure(threeNumbers), n1);
let supermap2 = maybeSuperMap(supermap1, n2);
let supermap3 = maybeSuperMap(supermap2, n3);
console.log(supermap3); // Prints Just: {"value": 16}
```

Listing 8 - Example usage of the Maybe applicative in TypeScript.

3.1.2. List applicative functor

Lists are not only functors, but also applicative functors. Functors wrap regular values, while applicative functors wrap functions. So, a list applicative functor would be just a list of functions. The supermap function should then apply all those functions within a list, to a list of values. The supermap function combines the functions in the first list with the values in the second list by the Cartesian product. If the list of functions has *m* elements, and the list of values has *n* elements, then the resulting list must have $m \times n$ elements. This sort of behavior is necessary in order to satisfy the applicative functoriality conditions [5]. Second, if only some of the functions were applied to only some values, how would one choose the functions or the values that should be excluded from the product? Third, in category theory, a list can be considered an object with non-deterministic value (it contains multiple values simultaneously). So, the product of two lists, as they are non-deterministic values, should contain all possible combinations of all the values, which is exactly what Cartesian product is. The pure function, which needs to keep the minimal context of the original value, just puts the value into a singleton list. Implementation of the List applicative in TypeScript is a lot more difficult than the Maybe applicative, because of the concatMap function needed in the supermap implementation. The concatMap function, in turn needs the concat function to be implemented, which needs the fold function to be implemented, which needs the joinLists function to be implemented (Listing 9). All this requires a lot of work and functional programming knowledge, as well as good knowledge of TypeScript peculiarities.

```
function listMap<T, U>(f: (x: T) => U, l: List<T>): List<U> {
    f = curry(f);
    if (l instanceof Cons) {
        let {head, tail} = 1;
        return new Cons(f(head), listMap(f, tail));
    return new Empty<U>();
}
function fold<T>(product: (1: T, r: T) => T, accumulator: T, xs: List<T>): T {
    if (xs instanceof Cons<T>) {
        let {head, tail} = xs;
        return product(head, fold(product, accumulator, tail));
    }
    return accumulator;
}
function listAdd<T>(x: T, l: List<T>): List<T> {
    return new Cons(x, 1);
}
function join<T>(l1: List<T>, l2: List<T>): List<T> {
    if (l1 instanceof Cons) {
        let {head, tail} = 11;
        return listAdd(head, join(tail, l2))
    }
    return 12;
}
function concat<T>(1: List<List<T>>): List<T> {
    return fold(join, new Empty<T>(), 1);
}
function listConcatMap<T>(f: (x: T) => List<T>, l: List<T>): List<T> {
    return concat(listMap(f, 1));
}
 listPure<T>(x: T): List<T> {
    return new Cons(x, Empty<T>);
}
function listSuperMap<T, U>(fs: List<(x: T) => U>, xs: List<T>): List<U> {
    fs = listMap(curry, fs);
    return listConcatMap(f => listMap(x => f(x), xs), fs);
}
```

122

Listing 9 - Implementation of the applicative functions for the List type in TypeScript. Implementation of necessary helper functions is also shown.

The supermap function applies all the functions in the first list to the values in the second one. This produces a list of lists, that is, a list of results for each of the functions for a specific value. This list of lists is then flattened to a single list using the concat function. The list supermap function is very useful for implementing the list comprehension mechanism. List comprehension is a mechanism to process lists in a quick and readable way, and it is common in languages known for their expressiveness and readability like Haskell and Python. TypeScript doesn't have the list comprehension mechanism, but it can be implemented, to an extent, using the supermap function for lists (Listing 10).

With all the necessary functions implemented, the List applicative can be used in the same way as it would be in Haskell (Listing 10). It is up to the programmers themselves to decide whether the benefits of the List applicative outweigh the effort necessary to implement it. In general, if there is a combining function f that combines n elements from n lists, the lists can be combined if it has the following type:

function combine<T>(x1: T, x2: T, ..., xn: T)

The combination would then be achieved by chaining a sequence of n supermap calls similar to the one in Listing 29.

```
function combine<T>(a: T, b: T) {
    return new Cons(a, new Cons(b, new Empty<T>()));
}
let l_left = new Cons(1, new Cons(2, new Empty<number>()));
let l_right = new Cons(11, new Cons(12, new Empty<number>()));
let _cartesian = listSuperMap(listPure(combine), l_left);
let cartesian = listSuperMap(_cartesian, l_right);
```

Listing 10 - Example implementation of Cartesian product using the List applicative functor in TypeScript.

4. CONCLUSION

This paper provided theoretical explanations of the Functor and Applicative Functor concepts in category theory. It then provided their implementations Type-Script, focusing on Maybe and List functors. Their use-cases were then shown, where it was demonstrated that they could be useful, especially when abstracting complex concepts, so they could be used and invoked on-demand, usually with a simple command. This paper had also shown that, because TypeScript is a multiparadigm language, the implementation of these concepts is not significantly more difficult, or different, to their implementation in Haskell, and the only drawback of TypeScript is that the return types of some functions cannot be statically type-checked. Thus, for a programmer that is well-versed in functional programming and wants to speed up or improve some of their work, TypeScript provides a good support for implementation of functional programming concepts.

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INFORMATION TECHNOLOGY SESSION

APPLICATION OF COMPUTER NETWORK SIMULATION SOFTWARE IN VIRTUAL ENVIRONMENT

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Abstract:

The development of information technologies enabled interactive teaching and the application of various software in education. The paper analyzed problems observed in the standard way of teaching in the field of computer networks. The aim of this paper is to prove that the application of computer network simulation software in teaching can improve the understanding of the materials in the field of computer networks. A comparative analysis of three computer network simulation software (Cisco Packet Tracer, GNS3 and OPNET) was performed regarding of use of these software in teaching. It is shown why Cisco Packet Tracer is the best solution for entry-level education in this area. By creating a simple computer network using Cisco Packet Tracer software, the necessary initial theoretical knowledge of computer networks is presented. It has been shown that the application of computer network simulation software cannot replace the classical form of teaching but represents good support in mastering complicated theoretical concepts in the field of computer networks.

Keywords:

Computer networking, computer network simulation, Cisco Packet Tracer.

INTRODUCTION

The intensive development of information technologies directly affects changes in the educational system. These changes imply greater use of interactive teaching, as well as the use of appropriate software that enables the simulation and visualization of complicated theoretical concepts which improves the understanding of the material [1].

Based on the recommendations of leading international organizations dealing with education, teaching in the field of computer networks represents a very important segment of the education of experts in the field of informatics and computing [2]. Due to the complexity of the computer networks concept, the sole study of theory in this field can not enable students to solve practical problems. The effectiveness of teaching mainly depends on the laboratory conditions in which its practical part is performed [3]. Conducting laboratory exercises with real network equipment is practically unfeasible due to the high cost of the equipment, its rapid development and the frequent need for upgrades. Real laboratories have limited access to the simultaneous work of many students.

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e-mail: ana.basic@its.edu.rs For the above reasons, the application of computer network simulation software is the best complement to theoretical teaching in this area.

This paper provides an overview of software that can be used in teaching in the field of computer networks. A comparative analysis of three software was performed: Cisco Packet Tracer, GNS3 and OPNET. An explanation is provided as to why Cisco Packet Tracer is the best choice for learning the basic principles of computer networks. The basic features of this software are presented and a detailed procedure for creating a computer network is explained.

2. ADVANTAGES OF USING COMPUTER NETWORK SIMULATION SOFTWARE

Computer network simulation is the process of creating a virtual version of a physical network. The application of computer network simulation software enables students to better understand the basic principles of computer network operation. Students have the opportunity to experiment with different network technologies and protocols, as well as to test different network management scenarios and strategies. For example, students can simulate network outages or package loss to analyse how the network performs in such situations. Also, they can analyse how the increase in the number of computers in the network affects the performance of the network, and how the IP addressing of computers, sub-netting or super-networking, etc. is done. These experiments can help students to learn by way of practical examples of how network management works and how the network can be optimized with the aim of achieving better performance.

Using some of the computer network simulation software, students are enabled to work in a virtual environment, simulate real network scenarios and test network performance. Most software provide the ability to set up and configure various network devices, which enables students to gain practical experience in working with the equipment.

The use of these software also allows teachers to create various simulations and scenarios related to specific topics that are theoretically covered during classes.

3. COMPUTER NETWORK SIMULATION SOFTWARE OVERVIEW

There are a lot of computer network simulating software. Some of them are developed exclusively for academic purposes and can not be used to simulate complex computer networks. On the other hand, there are also commercial software which are very complicated for use in teaching and do not provide appropriate displays of simulation results that would help students understand the operation of computer networks. Some of the most popular software that can be used in class are: Cisco Packet Tracer, GNS3 and OPNET. The main advantages and disadvantages of each of the mentioned software will be described.

3.1. CISCO PACKET TRACER

Cisco Packet Tracer is free software developed by Cisco Systems. This software contains detailed models of Cisco network equipment and is used to simulate computer networks. It has an interface that is very easy to use. It is intended for pupils, students and professors as a tool for learning and understanding the basic principles of computer networks.

Using this software, it is possible to configure various network devices, such as routers, servers, wireless access points, etc. Users can test their configurations and analyse how different network protocols behave in a real environment. It is also possible to connect network devices in different ways and to simulate different network scenarios [4].

Cisco Packet Tracer supports protocols of all levels of the TCP/IP reference model, such as IPv4, IPv6, OSPF, EIGRP, BGP, FTP, SMTP, HTTP, DNS, DHCP and others [5]. Cisco Packet Tracer enables one to create virtual computer networks (VLANs), configure security policies, including VPN (Virtual Private Network) and firewall configuration.

This software supports recording the created network session and its delayed playback. This allows the possibility of the processes and events that took place in the network to be analysed again, which positively affects the mastering of material from this area.

Cisco Packet Tracer is a good choice for all those who want to master the basics of computer networks and gain initial practical experience in this area. The downside of this software is that it is only limited to simulating Cisco devices, so it is not suitable for more complex network scenarios. Also, it does not contain all the features that are available in a real Cisco environment.

3.2. GNS3 (GRAPHICAL NETWORK SIMULATOR 3)

GNS3 is free and open-source software. It is often used in advanced computer networking courses. This software allows students to simulate various network configurations and scenarios with many components. The software supports the use of various types of network equipment including Cisco, Juniper and MicroTik [6]. GNS3 can be used to create a variety of network topologies, including networks with multiple routers, servers, and other network components. This software supports various types of operating systems, including Cisco IOS and Juniper JUNOS [3]. GNS3 is available for Windows, Mac and Linux platforms.

Using GNS3, students are enabled to create virtual network environments, as well as to simulate different scenarios in virtual network conditions. This is possible because GNS3 supports integration with virtual environments such as VMware, VirtualBox and Docker.

GNS3 has many advanced features and allows users to create very complex and realistic network configurations. The disadvantage of this software, from the aspect of use in teaching, is that it is not as easy to use as Cisco Packet Tracer. It takes more time to learn and use it in comparison to other computer network simulation software.

3.3. OPNET (OPTIMIZED NETWORK ENGINEERING TOOLS)

OPNET was developed as a tool for research and development of computer networks. It is used in a variety of industries, including telecommunications, transportation, energy, military, and others [7]. It is also used in advanced courses and in research in the networking industry. For teaching purposes, a specialized free version of the OPNET IT Guru - Academic Edition software is used. This version is used in over 500 universities around the world [3]. This version of the software is designed to complement specific lab exercises to teach fundamental networking concepts.

OPNET enables the examination of an existing network to find and eliminate errors, check the network configuration before it is built, and plan the durability and capacity of the network, plan the development of applications and other issues related to network technology [2]. OPNET enables performance analysis of network protocols and applications, such as bandwidth, latency, packet loss, and other parameters. Also, this software enables the automatic generation of scenarios for testing network performance and simulating different scenarios. One of the advantages of OPNET is that it supports different types of network technologies, including wireless and fixed network technologies such as LTE, WiMAX, ZigBee and others. There is also the possibility of integration with other simulation tools, such as MAT-LAB and Simulink, which allows performing highly complex network performance analyses [2].

OPNET is quite expensive software and complex to use. Its use requires a certain amount of knowledge of network technology and the simulation concepts. However, OPNET is a powerful tool for simulation and analysis of computer networks and provides deep insights into the performance of network systems.

4. SELECTED SOFTWARE FOR SIMULATING COMPUTER NETWORKS COMPARISON

Selected software for simulating computer networks can be compared according to several criteria, such as: complexity, functionality, availability, the necessary level of initial knowledge, etc. A comparative analysis based on the mentioned criteria led to the conclusion that Cisco Packet Tracer is the best choice for use in teaching by students who are just getting to know the basics of computer networks.

When we analyse the complexity of the mentioned software, Cisco Packet Tracer stands out for its simplicity of operation. This software is best suited for beginners who are new to computer networks and are not familiar with complex network configurations. It has an interface that is very easy to use.

When analysing software functionality, Cisco Packet Tracer stands out for its large number of preconfigured network elements and devices. This enables students to easily create different network configurations and experiment with different network scenarios.

In terms of availability, Cisco Packet Tracer is available on various platforms including Windows, MAC OS, and Linux, which makes it accessible to a wide range of users. This software is free to download and use, making it available to all schools and colleges.

5. THE CISCO PACKET TRACER PROGRAM WORKING ENVIRONMENT

The graphical environment of the Cisco Packet Tracer program is very simple and contains options that are characteristic of most application programs. The upper toolbar contains the *File*, *Edit*, *Options*, *View*, *Tools*, *Extensions*, *Window* and *Help* menus. For educational use, it is very important that within the *File* menu, by selecting *Open Samples*, one can access many typical network scenarios created. Network scenarios are divided into five areas, namely: *Networking*, *Infrastructure Automation*, *Cybersecurity*, *IoT* and *Programming*. On each predefined network scenario, it is possible to make various changes (for example, adding cards to modular routers and switches) and to perform network performance analysis.

This program supports the display of logical and physical workspaces. This is particularly important for teaching applications. The logical desktop shows the logical network topology, while the physical desktop allows students to see how the created network looks in space and how devices are physically connected and organized into sectors. In the lower palette of this program, there are tools for selecting network devices. Devices are divided into the following categories: Routers, Switches, Hubs, Wireless devices, Connections, End devices, WAN Emulation, Custom Made Devices, and multi-user connections. Additionally, in the lower palette, it is possible to choose between two operating modes: real-time or simulation operating mode. Both modes have equal importance in teaching. The application of real operation mode allows students to get a feel for network device performance in practice. Application of the simulation work model allows students to control the time intervals of data transmission through the network.

6. CREATING A SIMPLE COMPUTER NETWORK

Creating a simple computer network consists of several stages: selecting network devices, configuring network devices and checking the created connections. Supposedly it is necessary to create a computer network whose topology is shown in Figure 1 and the addressing scheme is given in Table 1 [8].



Figure 1 - Simple computer network.

		U		
Device	Interface	IP Address	Subnet Mask	Default Gateway
PC	Ethernet0	DHCP		192.168.0.1
Wireless Router	LAN	192.168.0.1	255.255.255.0	
Wireless Router	Internet	DHCP		
Cisco.com server	Ethernet0	208.67.220.220	255.255.255.0	
Laptop	Wireless0	DHCP		

Table 1 - Addressing Table [8].

6.1. SELECTION OF NETWORK DEVICES

Creating a computer network begins with selecting network devices and placing them in the workspace. After network devices are selected, their labels can be changed. By clicking on the device in the workspace opens a window in which the *Config tab* should be selected. The name of the network device can be changed in the *Display name* field. During IP addressing, it should be ensured that the addresses are within the permitted range. The most commonly used range in LAN networks is 192.168.0.0 – 192.168.255.255. The computer in this example is assigned the address 192.168.0.1. The Default Gateway address is set later, i.e. after setting the network address to which the computer will belong. After that, the DNS server address is set. The next step is to connect the network components. A copper straight-through cable is used to connect the PC and the wireless router. The same cable is used to connect the wireless router and the cable modem. A coaxial cable is used to connect the cable modem and the Internet Cloud. Next, a copper straight-through cable is also used to connect the Internet cloud and the server.

6.2. CONFIGURING NETWORK DEVICES

The next stage in creating a computer network is configuring network devices. By clicking on the wireless router located in the workspace, it is necessary to select the *GUI* tab to see the configuration options of this router. After that, it is necessary to select the *Wireless tab* and change the *Network Name (SSID)* in the resulting field. Setting the network name is shown in Figure 2.

hysical Config	GUI Attributes						
Vireless N Broad	band Router						
Wireless	Setup Wireless	Security	Access	Wire Applications & Gaming	less-N Broi Adminis	adband Router tration	WRT300N Status
Basic Wireless Settings							
	Network Mode:		Mixed		~	Help	
	Network Name (SSID):		Ana				
	Radio Band:		Auto		· ·		
	Wide Channel:		Auto		~		
			1.24120Hz		~		
	Standard Channel:		1 - E. + IE OF NE				

Figure 2 - Setting the Network Name.

Next, in the *Setup tab* under the settings for the DHCP server, it is necessary to check whether the *Enable* button is turned on and set the static address of the DNS server to 208.67.220.220. Save the settings by clicking *Save Settings*. The IP address of the router is 198.168.0.1 and the subnet mask is 255.255.255.0. The DHCP Server is activated and the starting address is 192.168.0.100. The maximum number of user addresses is 50, therefore the range of IP addresses is from 192.168.0.100 to 192.168.0.149. The static address of DNS1 is 208.67.220.220.

To create a wireless connection between the laptop and the wireless router, it is necessary to change the configuration of the selected laptop. By clicking on the laptop in the workspace, a list of modules is obtained under the *Physical tab*. Firstly the laptop should be turned off by clicking the power button. Then it is necessary to remove the installed Ethernet copper module by simply dragging the module to the part of the window where there is a list of modules. Next, it is necessary to install the WPC300N wireless module by simply dragging it toward the laptop. After installing the module, it is necessary to turn on the laptop. When the wireless module is installed it is necessary to connect the laptop to the network. By clicking on the laptop, in the *Desktop tab*, the *PC Wireless* icon should be selected. When the Wireless-N Notebook Adapter display appears, select the *Connect tab*. Next is to check if the network that was created appeared in the list of wireless networks. You need to select that network and click on the *Connect tab*. It is necessary to select that particular network and to click on the Connect tab. At that moment, the indicator will appear in the workspace signalling that the laptop and a wireless router are connected through a wireless connection.

The next step is to configure the PC. Firstly, it is necessary to click on PC, and then in the *Desktop tab*, the *IP Configuration* option should be selected. Within this window, it is necessary to select the DCHP radio button in order for the PC use DCHP to receive an IPv4 address from the wireless router. The *IP Configuration* then closed. Next click on the PC to open the *Command Prompt* window as shown in Figure 3 and use the *ipconfig/ all* command to check whether the PC has received an IPv4 address from the 192.168.0.X range.

The next step is to configure the Internet cloud. Two modules are necessary for the correct operation of the network, PT-CLOUD-NM-1CX module for cable modem connection and module PT-CLOUD-NM-1CFE for copper Ethernet connection. These modules are added within the Logical tab. After that, it is necessary to select the Cable option in the Config tab under the Connections menu. In the first drop-down menu, select Coaxial, and in the second drop-down menu, select Ethernet.



Figure 3 - Ipv4 address control using the ipconfig/all command.

Server0								_		
hysical Config	enices Desktop	Programming A	dtributes							
SERVICES	-			DH	CP					
HTTP	Interface	East	Other and D		Queine	0.00		0.04		
DHCP	interace	1.900	Linemetu	~	ORIVICE	O On		0.04		
DHCPV6	Pool Name	Pool Name			DHCPpool					
TFTP	Default Gateway	ault Gateway 208 67 220 220								
DNS										
SYSLOG	DNS Server	DNS Server			200.67.220.220					
AAA	Start IP Address :	208	67			220		1		
NTP	Submit Mark 10	5	266			265		0		
EMAIL		*	4.00		-	***				
FTP	Maximum Number of	of Users :			50					
IoT	TFTP Server.				0.0.0.0	0				
VM Management										
Radius EAP	WLC Address				0.0.0.0	2	_			
		4dd		Si	ave			Remov		
	Pool Name	Default Gateway	DNS Server	St Add	p hess	Subnet Mask	Max User	TFTP Server	WLC Address	

Figure 4 - Configuring DHCP server.

The last thing to configure is to make the server work as a DHCP server. Within the Service tab of the server shown in Figure 4, the DHCP option should be selected and the following parameters should be set: Pool name: DHCP pool; Default Gateway: 208.67.220.220; DNS Server: 208.67.220.220; Starting IP Address: 208.67.220.1; SubnetMask: 255.255.255.0; Maximum number of users: 50.

Then it is necessary to configure the DNS server to provide the domain name to IPv4 address resolution. This is done by selecting DNS in the *Service tab* and entering the following parameters: Name: Cisco.com, Type: A Record; Address: 208.67.220.220.

It is also necessary to make global settings and select *Settings* in the *Config tab* and enter the following parameters: Gateway: 208.67.220.1; DNS Server: 208.67.220.220.

Finally, it is necessary to adjust the FastEthernet settings of the Cisco server under the FastEhernet option located in the *Config tab*. Enter the following parameters: IP Configuration: Static; IP Address: 208.67.220.220; Subnet Mask 255.255.255.0

6.3. CHECKING THE OPERATION OF THE CREATED NETWORK

It is necessary to check whether the PC receives an IPv4 address from DHCP. By selecting the PC's *desktop*, the Command Prompt icon should be clicked. After the *ipconfig/release command*, *the ipconfig/renew* command should be entered. If the network is configured correctly, the PC should get an address from the 192.168.0.X range. The connection to the Cisco server is checked with the *ping* command. The response to the specified network commands is shown in Figure 5.



Figure 5 - Checking the created network with ipconfig/renew and ping commands.

7. CONCLUSION

The application of computer network simulation software in teaching has great potential to improve the quality of education. Each of the network simulation software has its advantages and disadvantages. The decision as to which software is best to use for educational purposes depends on the needs of the course, the level of education of the students, available time and budget. Here, a comparative analysis was made out of three software: Cisco Packet Tracer, GNS3 and OPNET. It is shown that Cisco Packet Tracer software is the best choice for the initial level of education in the field of computer networks. To create a simple computer network shown in this work, only basic knowledge of the characteristics of network devices, how to connect and configure them, the concept of IP addressing, as well as basic network commands was necessary. This means that the virtual network laboratory is not a basic tool, but only a support in overcoming the complicated theoretical concepts in the field of computer networks.

It is very important to include computer network simulation software in the educational program, to support students in their use and to create a special teaching plan. Future research should analyse how much the application of computer network simulation software helps students to improve their understanding of the material in this area.

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INFORMATION TECHNOLOGY SESSION

PFSENSE ROUTER AND FIREWALL SOFTWARE

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Abstract:

The pfSense is a software system that combines router and firewall in one product. This is a stable operating and simple to use cybersecurity solution for implementation in computer networks. This software package is intended for wide range of users, from individual clients to small, medium or large enterprises. The pfSense is one of the world's leading router, firewall, as well as VPN solution for secure cloud networking and network edge based on an open-source software platform.

The computer networks utilizing the pfSense system, have significantly higher degree of control and better management of incoming Internet traffic, which tends to become more and more extensive over time. The set of performances is what makes it unique and exceptional while also surpassing the existing competitors in that area. This open source network security solution raises the overall cybersecurity and accompanying parameters to a significantly higher levels.

The pfSense software brings users and developers together. There is a large community which is strongly supporting it, while constantly evolving and upgrading it too. Though pfSense can be downloaded, installed and used free of charge, it is possible to make commercial support to the pfSense's developers team. There is also an enhanced version, pfSense Plus software package combined with Netgate hardware, providing capabilities such as prevention of specific attack mechanisms, proxy filtering, network services, user authentication, monitoring of either traffic or device, all at an affordable price.

Keywords:

pfSense, Router, Firewall, Computer Network, Traffic Control.

INTRODUCTION

pfSense is a specialized software, a free network firewall distribution, based on the FreeBSD operating system with a custom kernel and option to include the third party free software packages for additional functionality [1].

It serves as a firewall and a router simultaneously, for networking computers. [1]

This software was created in 2004. as a project by two students Büchler and Ulrik, but officially have appeared in October 2006. as fork of the original m0n0wall firewall project in FreeBSD operating system distributions. In addition to amateur use, pfSense also provides the possibility of installing a professional version and consequently specific settings for companies and organizations. [2]

pfSense software is a free, custom, open-source FreeBSD distribution specifically aimed for use as a firewall and router. It is fully managed and adjusted through a standard web environment. In addition to being a powerful, flexible firewall and router platform, it includes a long list of related features and system packages, which allow further extensibility without adding unnecessary options and potential security vulnerabilities to the base distribution.

The pfSense software is constantly being improved, and the latest version of it is 2.6.02.

pfSense now represents the world's leading opensource firewall, router and VPN solution for secure networking at network edge and in the cloud. Already several million installations of different versions of this software are active worldwide and they protect numerous computers in homes, companies, government offices, educational institutions, directly or indirectly through Internet Service Providers (ISPs). [1]

2. GENERAL PFSENSE FEATURES

pfSense can be viewed as a type of operating system, software for networking devices having open source code. It is based on FreeBSD operating system. Due to the large number of initial compatibilities, the pfSense team chose this type of operating system (FreeBSD) as the base for the kernel. pfSense has excellent hardware portability. Other vendors software are no match to it. It provides highest level of cybersecurity completely free of charge. The pfSense has also open source code which means that expert users can adapt it to their needs. [2]

Other software do not have such capabilities, and even may not be tailored to suit the hardware, except for those specifically designed and made for that system (many router operating systems are dedicated software, locked to run on only one type of router and cannot be applied to another system). [2]

The complete documentation on installing and configuring the pfSense service is extensive, helpful, relevant, and open-access too. It is available for access on the official website of the creator of this product.

pfSense can be installed on a physical computer with operating system or on a virtual machine, and after appropriate settings, be put into full operation. The community gathered around this software is very active and creative - they collaborate with other software developers. Any of the pfSense users can make their own versions and improvements of the original software code through the Github platform. If a fork suggested is popular enough, or it fixes a bug, or adds a new features, the pfSense team can add that code as a part of the official pfSense software. This often happens in practice. [2]

pfSense software includes the same features as the most expensive commercial firewall solutions. In some cases it implements additional features that are not available in commercial, closed source software. It also supports hardware that is generally considered older, or even hardware that is not of the standard x86 architecture. Certainly pfSense offers a higher quality of service for the money invested. According to what characterizes it, the adequate implementation of the mentioned software follows. [2]

Installation and further configuration of pfSense is done according to available and very comprehensive instructions. In order to install it, it is necessary to open an appropriate account. Log-in into the system requires classic authentication - the software uses a typical username and password login form.

By following defined steps for a specific software implementation procedure, an old and obsolete computer can be transformed into a high performance network device which can be used as a router, firewall, server (DHCP, DNS...), intrusion detection system, intrusion prevention. All of the above mentioned is realized in single device, on one piece of hardware, with one software solution. In addition to the ones already listed, the pfSense system contains numerous other options, which makes it an excellent solution either for home or corporate needs, if it is combined with adequate hardware. Another feature of that system, apart from the possibility of installation with minimal requirements for hardware components, is the easy upgrade and portability of the system, considering that all settings remain memorized. [3]

pfSense is Free and Open Source Software, based on the Unix-based FreeBSD operating system. The minimum hardware requirements for pfSense is a 500 MHz processor (for a throughput of 10 Mb/s - 20 Mb/s), while a throughput of 21 Mb/s - 100 Mb/s requires a 1 GHz CPU. A throughput of 101 Mb/s - 500 Mb/s requires a 2 GHz processor with PCI network cards, while above 501 Mb/s a multi-core CPU faster than 2 GHz is needed. [4] Future-proofing is a term that means the so-called "preparation for the future", and it is considered to be one of the most important notions/ terms in the IT field. This assumes that a system is made better, more powerful and with more features than is currently needed. pfSense adapts to the above needs and scales up to serve and satisfy increasing demands. In computer networks this means a higher number of possible interconnections, equipment providing higher Internet up-link and/or down-link speed and data transfer between the local network, servers having excess capabilities and more resilient than the current application demands and similar. [2]

In case of pfSense, an important strength is its possibility to modifying the code by the user. When proprietary operating systems and/or software for network devices are considered there is always the issue of security, as well as privacy. It is very difficult to find out exactly what data some software collects, and which data (packets) are sent over the Internet. Even for advanced users, who have the ability and expert knowledge to see the sent packets, in most cases (and most of the time) that data is encrypted and cannot be read by human without appropriate decoding. That's another reason why free and open-source software (FOSS) is getting more and more popularity - because of its transparency.

pfSense software includes the same features and provides many options as the majority of expensive commercial firewall solutions. In some cases, pfSense has additional features not available in commercial closed source solutions. [1]

Netgate's pfSense software is available in the Azure and AWS marketplaces, as well as their respective cloud platforms. Many organizations and enterprises rely on pfSense software to provide reliable, full-featured firewall protection in the cloud, without hidden feature fees, arbitrary licensing fees, and user restrictions. [1]

In some cases pfSense has successfully replaced major commercial firewalls, including Check Point, Cisco PIX, Cisco ASA, Juniper, Sonicwall, Netgear, Watchguard, Astaro, etc. Listed software includes a web environment for configuration of all its components. There is no need for any knowledge of UNIX, using commands and manually editing sets of rules. [1] Specific features that pfSense is providing include the following [5]:

- Firewall;
- Status table;
- NAT (Network Address Translation);
- Redundancy;
- VPN (IPsec, OpenVPN, PPTP);
- PPPoE server; and
- Dynamic DNS.

In wireless network configurations, it is easy to connect the WLAN access point (Access Point - AP) to the firewall, which protects / takes care of and provides connection to wireless devices (smartphones, tablets, etc.). This type of configuration with network devices and introducing pfSense system as a boundary between LAN and WAN, is presented in Figure 1. Although there are mini computers and routers for pfSense, equipped with a WLAN chip, very few of these devices can work in the access point mode. In most cases, they only support client mode, so they can connect to a WLAN. In addition, pfSense only supports a few tabs for access point mode. [6]

pfSense is a free, Open Source firewall and router, based on a FreeBSD platform, which is popular for its reliability, transparency and a clear, user-friendly interface. In addition, it is an indisputable fact that it includes numerous functionalities, which are characteristics of commercial, more expensive firewall/router products. [7]

The pfSense Plus is more advanced software made by Netgate, the networks router and firewall for cloud. It is a robust, resilient, reliable and safe software product. It is currently the most reliable firewall on a global scale. This software has gained the respect and favour of users, and has been installed more than seven million times worldwide, having over 50 software releases since its inception in 2001. (Figure 2). The software is fully operational thanks to support of open source technology. pfSense Plus has over seven million installations protecting, businesses, homes, governments, educational institutions and service providers.

The pfSense Plus software package features a number of advanced options. Among these the most important are the following: mechanisms for preventing attacks from the network, setting up proxy traffic filtering, secure/ certain network services, authentication of users at login, monitoring of the network and its segments. [1]







Figure 2 - pfSense Plus important numbers.

The software includes the same features listed as more expensive commercial firewall solutions provide. In addition pfSense includes additional features that are not available in standard vendor or proprietary source solutions. Organizations across the world rely on pfSense software to provide reliable, full-featured firewall protection in the cloud.

There are no hidden features and functions fees, no arbitrary licensing fees, and no artificial user limitations. [1]

The main properties of pfSense Plus software, from technological, business and utilization aspects, in Table 1 are presented in detail. [1]

3. PFSENSE SECURITY

The level of security in the pfSense system is incomparable (is much higher) to the maximum level of security provided by an ordinary router. The most significant item is the fact that the firewall is modular and receives constant updates, so that when new types of attacks appear, the system can be preemptively protected against them as potential threats.

In a professional environment, the capabilities of pfSense are almost outstanding, ranging from address blocking, remote server monitoring, making notifications about new MAC addresses, address separation and a large number of different packages that additionally secure the network.

Open Source Technology	Proven Success	Business Assurance	Deployment Flexibility
• Trusted and preferred by many organizations	• Over seven million installs serving literally every continent	 24/7 global support options Get prompt responses to 	• Home, remote office, head- quarters and data center
• 3x-5x lower total cost of ownership than traditional solutions	• Widely deployed in critical business, government and educational IT	 Get prompt responses to critical issues from Netgate experts who consistently exceed SLA expectations Professional services and training for specialized needs 	 premises installations Turnkey appliance and virtual machine instances
Avoids vendor lock-in	infrastructures		
• Faster response to critical security vulnerabilities	 15+ years of continued innovation across 53 releases and counting 		Cloud ready - AWS or Azure Marketplaces

Table 1	- Addressi	ng Table	[8]
1 abic 1	110010331	ing rable	lol

For a network administrator, these capabilities mean a lot, because no commercial router has this level of safety and security. That is why many medium and small IT companies are now switching to the pfSense for router and/or firewall solution. Large IT enterprises often use a combination of multiple services, and even write their own services and programs designed to protect the network. The level of protection provided by pfSense is high, but there are options to open ports, rules on both sides of the network (WAN/LAN), the possibility to create virtual addresses to block access. [2]

As an extremely powerful, robust, yet easy-to-use software solution, pfSense software combines and delivers simultaneously firewall, router, and VPN functionality to users. These are intended for cybersecurity implementation and use in homes, companies (small and medium size enterprises), educational and scientific institutions (faculties, schools, institutes) and government agencies, making computer networks more resilient and safer.

With additional packages, which are often used in pfSense, a computer network quickly becomes very secure from Internet threats. However, this requires a higher level of knowledge that is not common, so the average user is recommended to keep everything at the factory settings. There always is the possibility of a configuration error, which can also create even bigger problems in a computer network.

In addition, there is an additional level of protection from a pfSense. The option to add open VPN networks directly to the router enables encryption of data sent over the Internet. fBlockerNG prevents the download of unnecessary advertising cookies or packages and traffic analytics that are often transferred by computers. Known suspicious websites can be blocked or avoided, silent ping is provided and sending of appropriate data. [2]

4. CONCLUSION

pfSense as a system protection management, traffic control and cybersecurity software is a good choice. Experts in the field, computer network administrators rely on it worldwide. In addition to being completely free, the code is open source and is continuously updated with the new versions. The community gathered around the pfSense software is very active and provides constant upgrade and support. It also provides unparalleled portability - compatibility with a variety of different hardware devices that might not be used in a computer networks otherwise. When comparing the capabilities of a computer network based on and protected by pfSense, to a network of approximately the same complexity, and qualities, only based on proprietary software and hardware, there is huge difference in their investment cost. Often, most proprietary options, especially those offered by Internet service providers, are of low level quality and simply cannot be compared to the capabilities of open source software.

The features provided by open source software excel more and some of the highest quality software today have this kind of code. The number of users of open source software is increasing significantly and growing linearly with the number of active developers who are searching for a better alternative to vendor solutions. The number of users switching to the Linux operating system, as well as all possible distributions of that system, is growing more and more, following the number of active developers who strive to provide the best possible software code. Due to the UNIX subsystem, there is a high number of options available in the standard Linux operating system. Also, as OpenBSD improves, so does pfSense becomes almost perfected over time. As new hardware emerges, the scope of pfSense's functionality increases

Today, pfSense is often used for various tasks, from large and medium-sized enterprises, and also in small, home or personal computer networks. It is especially applicable in networks having a large number of wireless connected users, or a server. Since the mentioned system is very easy to configure and set up, users can be laymen or experts alike.

With increase in bandwidth demands, higher internet speeds, many obsolete routers become bottlenecks in the data flow between network segments and internet. Due to the modularity of pfSense, and the power of modern desktop processors, the pfSense system can reach packet transfer data-rate above 100 Gb/s. With several thousands of companies using pfSense software, pfSense becoming one of the world's most trusted open source network security solution.

Providing comprehensive network security and control solutions for large companies, Netgate with pf-Sense Plus software brings together the most advanced technology available to make network protection more effective than ever before. These products on the most reliable platforms are configured and to provide the highest levels of performance, stability and cybersecurity are designed.

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SINTEZA 2023 INTERNATIONAL SCIENTIFIC CONFERENCE ON INFORMATION TECHNOLOGY, COMPUTER SCIENCE, AND DATA SCIENCE

ADVANCED TECHNOLOGIES AND APPLICATIONS SESSION INVITED PAPER

MATHEMATICAL MODELING AND FILE SYSTEM PERFORMANCE EXAMINATION FOR TYPE 1 HYPERVISOR WITH FULL HARDWARE VIRTUALIZATION IN THE CASE OF KVM AND MS HYPER-V

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Abstract:

The paper analyses the performance comparison of hypervisor type 1 in the case of KVM and MS Hyper-V platforms for virtualization. The characteristics of both tested hypervisors were examined through file system performance. The tests were performed under equal conditions and with an inimitable testing methodology, using the benchmark program - Filebench.

The performance of the tested hypervisors was compared taking into account tests performed for a system with one, two and finally three virtual machines in state of operation. Mathematical modelling was done, which is the main contribution of this work, then hypotheses about the expected behaviour were set and confirmed through the obtained results. Ubuntu 22.04 LTS, an OS (operating system) from the Debian distribution family, was execute as the guest OS.

Keywords:

MS Hyper-V, Linux KVM, Ubuntu OS, Virtual Machines, File System Performance.

INTRODUCTION

Virtualization is a technique used in information technology to create a virtual representation of computer resources. The term "virtualization" refers to the simulation of software or hardware by another software package. IBM first used virtualization in the 1960s as a technique for logically allocating mainframe computer system resources to various applications. Since there is no longer a requirement to maintain the "one server, one application" concept, today is possible to execute numerous operating systems on the identical physical platform. Utilizing such a system has numerous benefits and cost reductions, including those related to hardware, CPU, memory, and administrative personnel.

All of this is positive conclusion for virtualization in the area of reliability. Data migration from one server to another and the addition of new servers are both made simple by virtualization solutions. This adds to the technology's benefits in the area of scalability, which is considered a great improvement in hardware virtualization. Purpose of this paper is to compare two different tools of virtualization on same hardware and software resources. The most well-known and widely used type of virtualization is full hardware virtualization, which is the subject of this essay. VMM (Virtual Machine Monitor) is the name of the program that manages virtualization. Server virtualization is another name for the procedure of generating and managing virtual computers, and it is used most frequently in a professional IT setting. Type 1 (native) and type 2 (hosted) hypervisors fall into these two groups [1-2]. In this case study, type 1 hypervisors were put to the test for the virtual platforms MS Hyper-V and KVM (Fig. 1).



Figure 1 – Example of a type 1 hypervisor.

2. RESEARCH WORK, MOTIVATION AND GOAL

The majority of the papers in this area focuses on comparing hypervisor performance using various test methodologies and benchmarking tools. Most of these references represent quality case studies in which various system performances of hypervisors are measured and interpreted. While most of these references lack comprehensive mathematical modelling, their case studies still provide valuable scientific and practical contributions [3-8]. One of the pillars for achieving outcomes at the quality level is the employment of various tried-andtrue benchmarking tools for this purpose. Because Filebench is a versatile, potent, multithreaded solution that simulates the actual application workloads, using this powerful tool is advised. The same could be advice for Fio tool, a benchmark that is comparable to Filebench, as well as certain artificial benchmarks like Bonnie++ and Postmark.

Mathematical modeling of virtualization based on hypervisors in the field of file system performance and application of the model to a case study, through the interpretation of benchmark results, are the key contributions of this research. A similar mathematical model was previously used in the case studies presented in references [9-11]. Through our core module, using mathematical modelling, we successfully interpret the file system performance in various case studies. Because there are so many variables in a complicated virtual environment, the model predicts that there won't be a single winner hypervisor and that it will depend on the case study, or the workload characteristics. In terms of competitiveness, we are mandating a mathematical model, many case studies built on the concept, and real-world performance evaluations. Reducing infrastructure costs and hardware reduction, accompanied by simpler administration, make the server variation of virtualization a fantastic answer. However, there is still much opportunity for development and many unanswered questions.

The contribution of this study is the comparison and validation of two different hypervisors, MS Hyper-V and KVM, whose quality and performance we have examined under identical circumstances. The MS Hyper-V hypervisor is also suited for the usage of paravirtualization, but both of hypervisors use complete virtualization. The well-known Linux OS distribution Ubuntu OS 22.04. LTS as the guest operating system is employed, and the Filebench benchmark tool with four different workloads was used for testing purposes. A mathematical model was constructed once the hypotheses were established and was then verified by the observed data.

2.1. KVM AND MS HYPER-V

Microsoft created MS Hyper-V, an effective hypervisor that allows for the virtualization of operating systems in a server and PC (Personal Computer) context (Fig. 2). Microsoft has integrated a Hyper-V virtualization as a role into the operating system with the release of Windows 8 for PC and Windows Server 2008 R2 for servers. When is used in PC, Hyper-V acts as a hosted hypervisor. The difference when using Hyper-V in the server or PC version is reflected in the memory usage approach. The MS Hyper-V role permits the segregation of partitions in which guest OS will run and enables administrators to establish several virtual machines [12].



Figure 2 – Example of MS Hyper-V architecture.



Figure 3 – Example of KVM architecture.

142

KVM (Kernel-based Virtual Machine) technology is practically required for virtualization under the Linux operating system. It was developed initially as a Red Hat sponsored project. KVM is a core component of the Linux kernel since version 2.6.20 and is implemented as a kernel module. It is impossible to categorize the KVM as a type 1 or type 2 hypervisor. On the one side, KVM enhances and gives the Linux kernel virtualization features, enabling Linux to be used as a bar-metal hypervisor (Fig. 3). Conversely, Linux OS is a standalone operating system that provides the underlying functionality for KVM to operate independently. As a result, it can be claimed that KVM operates above the primary OS (type 2 hypervisor), employing already developed system functionalities in the absence of its own [13-14].

2.2. MATHEMATICAL MODEL AND HYPOTHESES ABOUT EXPECTED BEHAVIOUR

Both hypervisors are implemented in the microkernel architecture. Both hypervisor are native, working directly on the hardware. The following equation (eq. 1) can be used to get the total processing time for each Time workload (Tw):

$$T_{W} = T_{RW} + T_{SW} + T_{RR} + T_{SR}$$
 (1)

whereas T_{sR} and T_{RR} stand for sequential read and random read times, T_{RW} and T_{sW} stand for random write and sequential write data entering times, respectively. A file system with six input factors has the following estimated access time for each of these workloads (eq. 2):

$$T_{WL} = T_{FB} + T_{FL} + T_{J} + T_{HK} + T_{DIR} + T_{META}$$
 (2)

where T_{WL} stands for the total amount of time needed to complete all operations for a specific workload, and the input factors of equation (2) stand for the amount of time needed to complete all operations involving file blocks and lists, journaling, housekeeping, metadata, and directories in the FS (File System). The following five factors can affect the workload time T_w (eq. 3):

$$T_w = f(Bnk, GOS-FS, Hp-proc, VH-proc, HOS-FS)$$
 (3)

For both KVM and Hyper-V, the first and second parts, Bnk (Benchmark) and GOS- FS (guest file system), are the same. Since the same benchmark and virtual machines (with the same ext4 guest FS) were used for testing, it is reasonable to believe that these two factors will have an identical effect on the third input factor, Hp-proc (hypervisor processing). This is the period of time it takes the hypervisor to pass a request from the virtual hardware to the host drivers. QEMU full virtualization for KVM and MS full virtualization for Hyper-V make up the fourth input factor, known as VH-proc (virtual hardware processing).

Both hypervisors have their own solutions, and even while these are complete hardware emulations, their performance will undoubtedly vary. HOS-FS is the fifth input factor (host file system) of equation (3). KVM employs ext4 and the MS Hyper-V his NTFS file system. This input factor is anticipated to affect hypervisor processing times differently. Since the particular tests are designed to evaluate the performance of bar-metal virtualized guests, it is anticipated that the third, fourth, and fifth input factors of equation (3) will have the greatest bearing.

2.3. TEST CONFIGURATION AND BENCHMARK APPLICATION

It is important to use the identical hardware configuration, the identical guest OS, a high-quality benchmark test software, and the identical performance measurement methodology for testing to be appropriate and of high quality. The tests were conducted on Dell Vostro 15 3591, whose characteristics are shown in Table 1. Table 2 shows the characteristics of the hard drive used for the tests. As a guest OS, Ubuntu OS 22.04. LTS was employed.

The benchmarking software Filebench, version 1.4.9.1-3, was used for all experiments. This application may provide a huge number of workloads and is intended to assess how well file systems and storage function. Web, mail, and file server workloads are utilized to simulate settings in this article while employing services.

Processor	Men	nory	Hard disk	Host OS
Ryzen 7 3700U, 2.3GHz, 4C/8T	16GB	DDR4 Micron	2210 NVMe 512GB	Windows 11 Pro
	Table 2 - Hard d	isk environment/Microi	n 2210 NVMe 512GB.	
Device type	Capacity	NAND Flash memory type	Interface	Internal data rat
Solid state drive -		3D quad-level cell	1xPCI express 3.0x4	2200 Mbps (read)

Table 1 - Hardware environment/Dell Vostro 15 3591.

3. TESTING AND RESULTS

In this essay, the performance of various virtual server platforms is compared. Data throughput and disk performance were evaluated using Filebench tool. All virtual machines were developed with identical features in order to make testing meaningful (Table 3).

We updated the base code files varmail.f, webserver.f, fileserver.f, and randomfileaccess.f, for the purposes of mail, file, web and combination of previous three server testing. By first constructing a single test virtual machine on Windows 11 Hyper-V, which had been activated as a role, was tested. The environment is tested also with two and three virtual machines using the same process. There were ten tests, each lasting 120 seconds. The utmost result is an average of all the test results that were obtained.

The Hyper-V was deactivated and its virtual machines were uninstalled to clear the environment before testing the KVM virtual platform (running Ubuntu OS 22.04. LTS with the KVM option selected). Then, the KVM virtual platform was installed and tested using the same process. The same criteria were acquired for both virtual platforms in this experiment. Figure 4 show the "Varmail" workload testing findings.

The "Varmail" workload reveals that KVM has a little better performance score than Hyper-V. Along with the random read input factors, this workload also includes synchronous random write input factors, for which the effect of FS caching is minimal. Due to the fifth input factor of equation (3), where NTFS (New Technology File System) for this workload performed better in the FS pair, Hyper-V is superior in this instance (ext4 on ext4 compared to ext4 on NTFS).

Virtual processor	Virtual memory	Virtual hard disk	Guest OS
2	2GB	10GB	Ubuntu 22.04.1 LTS

Table 3 - Virtual machine parameters/Input factors and characteristics.





Figure 4 - Varmail test results.



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Figures 5, 6 and 7, show the outcomes of evaluating other workloads.

It is obvious that Hyper-V performs quite better than KVM for the "Fileserver" workload. The FS cache effect on the guest OS and host OS is considerable in a complicated workload like Fileserver where there are random and sequential write input factors, hence KVM loses mostly due to the third and fourth input factors of equation (3). Conclusion is that that KVM has higher hypervisor latency and worse virtual hardware processing.

We can observe that Hyper-V is once more somewhat inferior to KVM for the "Webserver" task. Due mostly to the fifth input factor of equation (3), or FS pair (ext4 on ext4 in comparison to ext4 to NTFS), and the combined effect of FS caching, Hyper-V manages little bit worse in the "Webserver" workload, which contains random read input factors and very few random write input factors.

The "Randomfileaccess" workload is another one where the winner can't be concluded with certainty. Because of the significant influence of FS caching, particularly for random write, on this workload, which has many asynchronous random write and random read input factors, KVM showed a bit better performance than Hyper-V. This is mostly a result of the solid cache effect in random write and the fifth input factor of equation (3), NTFS, or the FS pair (ext4 on ext4 versus ext4 on NTFS).



Figure 5 – Fileserver test results.



Figure 6 – Webserver test results.



Figure 5 – Fileserver test results.

4. CONCLUSION

In the world of information technology, virtualization has already shown its worth and found a suitable place. In addition to all the advantages this technology offers, it is important to highlight its significant contribution to protecting the environment and the fact that it may be utilized to great effect in the field of green technologies. In the research described in this paper, Hyper-V dominated the most complicated workload (Fileserver), whereas KVM showed somewhat better performance in varmail, randomfileaccess and webserver testing workloads. The differences in the file system of the host OS and the FS pair played a major part in the performance disparities for this type of hardware and experiment (ext4 on NTFS vs ext4 on ext4). Additionally, virtual hardware processing and hypervisor processing, which have been shown to be the most difficult workloads, differ much on these two hypervisors for Fileserver testing results.

Future research in this area might concentrate on testing various server kinds as well as other widely used virtual platforms.

5. ACKNOWLEDGEMENTS

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146

SINTEZA 2023

ADVANCED TECHNOLOGIES AND APPLICATIONS SESSION

THE IMPACT OF JOB AUTOMATION ON MEN AND WOMEN IN THE DIGITAL AGE

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Abstract:

Job insecurity represents the subjective perception that there is a possibility of losing one's current job, as well as fear and worry due to the possibility of losing one's job in the future. Many different factors influence the growth of job insecurity. One of them is the fact that most routine jobs and activities are becoming increasingly automated. The aim of this paper is to analyze the impact of job automation on men and women in the digital age. The results of the empirical research conducted in the period from December 2022 to January 2023, in which participated 126 women and 52 men showed that men were slightly more likely to believe that robots could replace them in the future. However, regardless of gender, the largest number of both men and women believe that robots will not take over their jobs.

Keywords:

Digital Business, Digital Age, Automation, Job Insecurity, Robots.

INTRODUCTION

Following the literature, since 2016, researchers were focused in large extent on topic of Industry 5.0. The European Commission officially declared the era of Industry 5.0 in 2021, indicating the transition to a more sustainable, humane, and resilient industry [1]. According to some authors, Industry 5.0 is a green and digital technological transformation aimed at creating a more sustainable and people-oriented industry [2]. There are also authors who argue that Industry 5.0 is significantly safer, more responsible, and more ethical comparing to Industry 4.0 [3]. Furthermore, Industry 5.0 is more focused on sustainability and a more humane approach, with the primary goal of producing personalized products and/or services through intensive collaboration between humans and robots [4].

In Industry 5.0, the primary purpose and goal of technology is to assist and facilitate people's work through a safe and inclusive work environment, physical and mental health, well-being, and respect for basic human rights, autonomy, dignity and privacy [1]. The contemporary work environment imposes an increasing need for robots and humans to work together, in harmony, according to their knowledge, skills and capabilities [5].

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e-mail: jelena.lukic@mbs.edu.rs By working together with humans and robots, it is possible to use all the advantages and potentials of human intelligence and intelligent work systems. Unlike Industry 4.0, whose primary goal was automation, Industry 5.0 strives for greater integration of humans and autonomous machines [6]. Autonomous machine is one in which decisions (in response to external inputs or signals of any complexity) are made within the system rather than by humans [7]. The most popular view is that autonomous machines - robots should interact with their environments without the need for ongoing human intervention [8]. One common question regarding automation is how it will affect men and women on their jobs. The aim of this paper is to analyze the impact of job automation on men and women in the digital age.

The paper is structured as follows. First, the position of women in the business world in the digital age is presented. The key characteristics and key jobs in which women are most often dominant are pointed out. Then the areas of automation in the age of Industry 5.0 and the results of studies examining the impact of automation on gender were emphasized. After that, the methodology of the conducted research is described and the results obtained from the research are presented with a discussion. In the conclusion are indicated key messages and suggestions for future research on this topic.

2. THE POSITION OF WOMEN IN THE BUSINESS WORLD IN THE DIGITAL AGE

The position of women has changed significantly throughout a history. In opposite to ancient Athens, where a woman did not have the right to vote, could not be appointed as a judge, or independently decide who to marry, where as a rule woman was illiterate and legally owned by her father or husband, the situation changed over time for the better. Today, women have the right to vote, they can be judges, they can independently decide who they will marry, they are usually literate and legally independent [9]. Furthermore, women have largely become part of the labor market, but they are still insufficiently occupying leadership and top management positions [10]. In addition, statistics show that women often work in lower paid jobs that are below their level of education and qualifications. One of the reasons is that women take on a significantly greater share of duties in family life, which contributes to them having less work experience and career breaks [11].

In the business world, women have been shown to have a higher degree of motivation, energy, enthusiasm, empathy, as well as highly developed communication skills, an expressed desire for all employees to be adequately and timely informed, and the need to provide each employee with constructive feedback. On the other hand, men have been shown to be better in the process of building knowledge based on past experience, in the process of innovating because they are open to new ideas and ready for changes, then better understanding the overall functioning of the organization, defining strategy, delegating tasks and responsibilities and persuasion other people in the quality of their ideas and proposals. Compared to men, women are better at assessing feelings in the work environment, which allows them to establish strong relationships with colleagues and to express their thoughts and ideas much more clearly [12].

Practice has shown that women are better in jobs where the emphasis is on interpersonal relations, knowledge sharing, assistance, organization and cooperation. These include education, healthcare, social protection institutions, state administration, human resources and similar. Many emphasize the importance of "flexibility at work" as a trait possessed by intelligent women who are full of self-confidence and which refer to the ability to quickly adapt to changes [13]. In the book "Why the best man for the job is a woman: the unique female qualities of leadership", based on the analysis of the careers of 14 women in management positions, it was indicated that women are capable of establishing new rules, of turning challenges into opportunities, and of communicating and spreading a set vision well [14].

The results of research carried out since 2015 by LeanIn. Org and McKinsey & Company entitled "Women in the Workplace" showed that the higher the hierarchical position, the less women are represented. However, over the years, there has been a slight increase in the number of women in managerial positions. The pandemic with the Covid-19 virus has also brought new conclusions related to women in leadership positions: namely, women leaders undertake additional efforts and efforts to support employees and assist them cope with work tasks in new conditions and circumstances [15]. Women have a higher degree of motivation, energy, enthusiasm, better communication skills, strive to keep all employees well informed, provide constructive feedback and set high goals. Men, however, are better at building knowledge based on experience, at innovating - they are open to new ideas and changes, at seeing the whole picture of the organization, defining strategy, delegating tasks and responsibilities, and convincing other people of the quality of their ideas and proposals.

3. THE IMPACT OF AUTOMATION ON WOMEN AND MEN IN THE AGE OF INDUSTRY 5.0

Automation of business processes and activities can be achieved by implementing various technologies. These can be different types and forms of robots, artificial intelligence systems, ATM devices, chat bots, algorithms and similar systems that do not require human participation in their work. The progress of modern information systems and technologies has enabled an ever-increasing scope for automation, not only of routine, but also of more complex and demanding business processes and activities.

Technological advancements have also contributed to a reduction in the burden of care work for large segments of the population. While technology has not achieved gender parity in the workplace, significant changes have occurred that have resulted in fewer hours worked in the household for many traditional caregivers. Consumer durables such as the washing machine, microwave oven, and personal computer have served as "liberation engines" for women in particular [16].

The way automation affects women and men vary due to different nature of work. Even when employed are engaged in the same job position, men and women perform different tasks and use different skills and knowledge [17]. Research conducted in Latin America showed that women have a higher average risk of automation due to the facts that men tend to be more engaged in information and communication technologies, science, engineering and mathematics tasks, while women perform highly routine activities such as tasks related to marketing and accounting [18]. The similar conclusion is obtained from the study of [19] whose results showed that 44.4% of employed women faced a moderate to high risk of automation compared with 34.8% of men. On the other hand, there are studies which indicate that men are on positions which require specialized technical skills, while women work on jobs that require more social skills that are difficult to automate [20]. For example, some authors point out that emotions and context cannot be automated [21]. Also, the way and content of communication, emotional intelligence, establishing good relationships and ethical principles belong to soft knowledge and skills that can't be automated [22]. On the other hand, it is important to point out that there are also authors who advocate the opposite point of view, namely that robots can perform certain tasks better than humans. Certain robots can communicate to the interlocutor exactly what is needed, in the right tone of voice, without the possibility of conflicts [22].

It is believed that men will be more exposed to the effect of automation because they are dominantly represented in more physically demanding jobs that are mostly repetitive and routine in nature and can be easily automated. These include: pallet transfer, packaging, dosing, palletizing, and so on. Additionally, modern technologies have made strong entrance into all spheres and enable the automation of some more complex and non-routine business processes and activities which are typical at higher hierarchical levels and managerial positions dominated by men. The automation process has a slightly weaker impact on women because they are traditionally dominantly represented in professions where social skills and emotional intelligence are expressed, which explains why it is much more difficult or almost impossible to automate these activities.

It is crucial to understand that everyone is unique and works in a unique context or situation. As a result, it is impossible to draw broad conclusions about the impact of automation on men and women that are universally applicable. Automation may increase efficiency, productivity, quality, and safety on the one hand, but it may also have negative consequences such as job displacement, technological-caused stress, and widening economic inequality on the other.

4. RESEARCH METHODOLOGY AND DESCRIPTION OF THE SAMPLE

In order to take insight into the extent to which men and women fear job loss due to automation, in this paper a survey was conducted using a questionnaire that consisted of three profile questions - gender, age, education and questions on a five-point Likert scale for which the respondents asked them to answer to what extent they believe that robots could replace them in the workplace.

A total of 178 respondents participated in the survey, which was conducted in the period from December 2022 to January 2023, of which 52 were men and 126 were women.

The largest number of men and women who participated in the research is up to 25 years old, followed by those between 25 and 35 years old. This implies that young people, who have a long working life ahead of them and who will very likely be surrounded by robots in their workplace in the future, participated in the research. In terms of education, over 90% of men and women have completed university, basic and master's studies, which indicate that the respondents have a high level of education.

	Men N	Men %	Women N	Women %
	Age o	of respondents		
Up to 25 years	38	73.08	88	69.84
Between 25 and 35 years	9	17.31	21	16.67
Between 36 and 50 years	5	9.61	16	12.69
More than 50 years	0	0	1	0.80
	The lev	vel of education		
High school	3	5.77	11	8.73
Faculty – basic and master studies	49	94.23	114	90.48
Faculty – PhD studies	0	0	1	0.79

Table 1 – Basic information about respondents.

5. RESEARCH RESULTS AND DISCUSSION

Respondents had the task of expressing their degree of agreement with the statement " I believe that robots would take out my job" on a scale from 1 (completely disagree) to 5 (completely agree). The results are shown in Table 2 and Figure 1. The largest number of both women and men disagree with this statement. Out of the total number, 65.38% of men do not agree, while the number of women who do not agree with the statement is slightly higher and amounts to 68.26%. This means that about two-thirds of respondents who took part in the research believe that robots will not take over their jobs. On the other hand, there are a certain number of respondents who believe the opposite: 19.23% of men believe that robots could replace them in their workplaces, while 15.07% of women believe the same. It should be noted that a certain number of respondents took a neutral position: 15.38% of men and 16.67% of women.

The mean value of the answers obtained from men and women is less than the threshold value of 3. However, the mean value is slightly higher for men compared to women, as shown in Figure 2.

The results showed that most respondents that participated in this research are "lulled and carefree" and do not see automation as a threat to their jobs. Bearing in mind technological progress, it is necessary to raise people's awareness of the need to acquire knowledge and skills that cannot be automated, such as: critical thinking, problem solving, creativity, communicativeness, cooperation [23], as well as emotional intelligence, ethical principles, curiosity, empathy, and logic [24]. However, it is unknown what new technological advances will bring. For example, unlike industrial robots that mostly performed routine and manual tasks, today robots are increasingly cooperating with people and performing more complex tasks. Advances in the field of artificial intelligence have contributed to robots starting to perform intellectual and non-routine jobs and activities [25]. It is safe to say that robots in the future will be more complex and will have better features and capabilities. For example, robots have built-in sensors that allow them to interpret emotions, then have eyes that look in the direction of the interlocutor and can set appropriate facial expressions according to the feelings of the interlocutor (recognition of danger, stress, fear) [26], [27].

1 ubic 2 Respondents answer on the statement 1 beneve that robots would take out my job

	Men N	Men %	Women N	Women %
Strongly disagree	19	36.54	54	42.86
Disagree	15	28.84	32	25.40
Neither agree nor disagree	8	15.38	21	16.67
Agree	7	13.46	12	9.52
Strongly agree	3	5.77	7	5.55







Figure 2 - Mean values for the statement "I believe that robots would take out my job".

6. CONCLUSION

In the digital economy, no job can be said to be immune to new technological solutions, especially to robots and automation systems and machines. The results of the empirical research conducted from December 2022 to January 2023, in which 126 women and 52 men participated, showed that men were slightly more likely to believe that robots could replace them in the future. Out of total, 19.23% of men believe that robots could replace them in their workplaces, while 15.07% of women believe the same. The mean value of answers for men which participated in this research was 2.23, while mean value for women respondents was 2.09. Those differences between men and women are relatively small. Due to that, it may be concluded that, regardless of gender, the largest number of both men and women believe that robots will not take over their jobs (mean values are lesser than 3). Obtained results may indicate that the respondents which participated in this research are quite lulled and feel secure regarding their jobs.

This research is accompanied with some limitations. To begin with, the number of respondents in this study is small and may not represent the entire population. As a result, the obtained results cannot be generalized or applied universally. They may be applied only to the respondents that participated in this research. Second, a five-point Likert scale was used in the survey, which is not always perfectly precise in assessing the complexity

of people's attitudes, particularly on novel topics. Third, the survey only included closed-ended questions, with no opportunity for respondents to write down and express their thoughts and ideas. Due to that, it was not possible to thoroughly examine and analyze their perceptions and attitudes.

In future studies, it would be useful to conduct a longitudinal study and analyze whether the attitudes and perceptions of men and women change in accordance with new technological advances and changes in the work environment. Also, suggestions for future research are to include a larger number of respondents from various spheres of education and job positions.

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ADVANCED TECHNOLOGIES AND APPLICATIONS SESSION

THE MAIN CONCERNS OF EMPLOYED PEOPLE REGARDING ROBOTS AT WORKPLACE IN THE DIGITAL AGE

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Abstract:

Robots are gradually becoming a part of workplace. A large number of businesses continuously introduce robots or robotic manufacturing systems. Employees are once again confronted with new technological achievements at work. The purpose of this paper is to highlight the main concerns of employees regarding the use of robots in the workplace. The empirical study, which took place in the period from October 2022 to January 2023, encompassed 94 participants. The findings revealed that the most common concerns were that robots do not possess capacity to react adequately in unexpected situations, that respondents would feel lonely if their co-workers were robots rather than people, and that robots lacked human flexibility and mobility. Findings obtained in this study can be used by decision makers and human resource managers with the aim to overcome the main concerns while implementing robots at workplace. It is highly likely that technological advancement will result in new type of robots which will have new features and characteristics that are increasingly human-like.

Keywords:

Employees, Digital Business, Digital Age, Robots, Agility.

INTRODUCTION

In the digital age, agility is a necessary precondition for the successful operation of any organization. Organizations face a lot of pressure to become agile in the time of turbulence, high dynamism, unexpected events, and unpredictable changes. Leaders must be able to respond quickly and effectively to all challenges and opportunities. Agility is the ability to respond and adapt to new situations while actively looking for opportunities and chances to position an organization for potential future situations. It refers to how quickly and effectively an organization and its employees spot opportunities and challenges in the environment and respond to them [1]. In the digital age, organizations must be able to change quickly. Furthermore, organizations should incorporate new formulas for success in a chaotic, unpredictable, and non-linear environment into their mindset. One of the most recent changes is the use of robots in the workplace. Robots are intelligent physical systems that are equipped with sensors, actuators, and a certain level of artificial intelligence.

They are programmed by computer algorithms to perform various tasks instead of humans or alongside them [2], [3]. There is a special type of robots - collaborative robots, or co-bots, which are designed to work and interact closely with humans, and which possess human-like characteristics [4].

In the time of fifth industrial revolution, organizations are increasingly incorporating robots [5], [6]. Due to that, humans are confronted with a new trend: robots as co-workers. The purpose of this paper is to highlight the most common concerns of employees regarding robots at workplace in the digital age. The primary research question is to identify the primary concerns of employed people regarding workplace robots. The paper is organized as follows. After introduction with key theoretical concepts, the second title focuses on research methodology and general sample information. The third title represents research findings and their discussion. In conclusion are summarized key findings, limitations of the research, as well as the recommendations for future research.

2. METHODOLOGY OF RESEARCH AND GENERAL INFORMATION ABOUT SAMPLE

The following research question (RQ) is imposed in this paper: What are the main concerns of employees about workplace robots? A questionnaire technique was used to answer this question. The questionnaire contained five questions. Gender, respondent age, level of education, and work-related experience with robots were the first four demographic questions. The fifth question was designed as a five-point Likert scale with five statements that respondents scored from 1 to 5 based on the extent they agreed with the statements. A score of 1 indicated that respondents strongly disagreed with the statement, while a score of 5 indicated that respondents strongly agreed with the statement. The questionnaire was tested on a sample of 30 people to determine its reliability and validity. Cronbach alpha coefficient for measurement scale was 0.79, indicating high reliability.

Between October 2022 and January 2023, the questionnaire was distributed online via LinkedIn network in various professional groups which consisted of employed people from various industries. The questionnaire was completed by 94 respondents. Conclusions based on the results of this research cannot be generalized, due to small sample size. The general information about respondents is presented in Table 1. In terms of gender, 72% of respondents are female, while 28% are male. Almost half of the respondents (49%) are under the age of 25, while 29% are between the ages of 25 and 35. There are also 22% of respondents between the ages of 36 and 50. The majority of respondents (85%) have completed bachelor or master's degrees, while 11% have completed high school and only 4% have completed doctoral studies. Research results showed that respondents do not have any prior workplace experience with robots. This result was unexpected, but it is not surprising given Serbia's technological development. Respondents had no experience working with robots. As a result, their responses are based on their perceptions and beliefs.

	Number	Percentage
	Gender	
Male	32	25.40
Female	21	16.67
A	ge of respondents	
Less than 25	46	48.94
Between 25 and 35	27	28.72
Between 36 and 50	21	22.34
L	evel of education	
High school	10	10.64
Bachelor/master studies	80	85.11
Doctoral studies	4	4.25
Work-relat	ted experience with robots	
Yes	0	0
No	94	100%

Table 1 - General information about respondents.

3. RESEARCH RESULTS AND DISCUSSION

According to the findings presented in Figure 1, the majority of respondents (59%) agree that robots lack human flexibility and mobility. Almost 30% of respondents are neutral on the statement, while 13% disagree. Respondents perceive robots as mechanical structures with limited spatial movement and coordination capabilities. This concern is justified, especially given that some types of robots must move autonomously in space and to the desired location. Warehouse robots, for example, must be able to move around factory floors, whereas assembly robots must be able to be moved to a desired location [7].





As it can be seen from Figure 2, more than two-thirds of respondents (67%) agree that robots may not know how to act in unexpected situations. More than one-fifth of respondents have a neutral attitude toward this statement, while 11% disagree. Respondents continue to believe that robots are programmed to act only in highly predictable and stable situations. It is highly likely that robots will be unable to respond appropriately in some unexpected situations. This statement is related to the previous one - robots are unable to perform some complex and challenging tasks that change frequently due to limited mobility and flexibility [8].



Figure 2 - Robots might not know how to act in some unexpected situations.

Several studies have found that people are concerned that robots will take their jobs and positions [9]. The findings of this study presented in Figure 3 revealed the inverse. Only 16% of respondents believe that robots will take over their jobs, while 19% are neutral. The majority of respondents (65%) disagree with the statement that robots could eventually replace them on the job. According to other studies, robots are frequent on many positions. They were primarily used in routine tasks and activities such as packing, picking, placing, welding, and gluing [10]. In the last couple of years, robots are becoming present in some creative and challenging positions such as travel agents, receptionists, customer service, and cashiers [11].



Figure 3 - Robots might take over my job.

Employees' feelings at work influence their behaviour and overall results. As it can be seen in Figure 4, nearly half of respondents (47%) disagree with the statement that they will have unpleasant feelings while working with a robot. There are an equal number of respondents (27%) who stated that working with a robot would be unpleasant for them and who are neutral regarding this statement.



Figure 4 - Working with a robot would not be pleasant for me.

As it is shown in Figure 5, almost half of the respondents (48%) stated that they would not feel unsafe while working with a robot. On the other hand, there are also 28% of respondents who said they would feel unsafe while working with a robot, while 24% of respondents are neutral. Safety is a fundamental requirement in the design of a robot, particularly in workplaces where humans must collaborate with robots [12]. In that sense, safety implies that there is no possibility of robot accidents or risky behaviour [7].



Figure 5 - Working with a robot would make me feel unsafe.

In Figure 6 are presented results regarding employees' feelings about robots as co-workers. More than twothirds of respondents (68%) said they would feel lonely if their co-workers were robots rather than people. This is not surprising given that every employee desires coworkers with whom they can exchange new ideas, opportunities, and suggestions. Furthermore, 15% of respondents disagree with this statement, while 17% of respondents are neutral.



Figure 6 - If my co-workers were robots instead of people, I would feel lonely.

The mean values for each of the questionnaire statements are presented in Table 2 and Figure 7. The statement that robots might not know how to act in some unexpected situations has the highest mean value (3.95). The majority of respondents still envision robots in a stable, predictable environment performing routine, monotonous, and standardized tasks.

The statement that people would feel lonely if their co-workers were robots instead of people has the second highest mean value (3.85). The majority of the working day is spent at work. Employees have the need for colleagues to converse with them about various aspects of work. As a result, interpersonal relationships in the workplace are crucial. Work takes on greater significance and meaning when people collaborate, supporting and learning from one another [13].

According to the mean value, the third position is reserved for the statement that robots lack human flexibility and mobility (3.74). The majority of respondents still see robots as mechanical machines with limited moves and coordination efforts, rather than as flexible and mobile machines.

Statements	Mean
Robots might not know how to act in some unexpected situations.	3.95
If my co-workers were robots instead of people, I would feel lonely.	3.85
Robots lack human flexibility and mobility.	3.74
Working with a robot would make me feel unsafe.	2.73
Working with a robot would not be pleasant for me.	2.72
Robots might take over my job.	2.17

Table 2 -	Mean	values	for	statements
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Figure 7 - Mean values for statements.

4. CONCLUSION

Employees have concerns and difficulties each time they are faced with new technologies and methods of work. In this paper, empirical research was conducted with the aim of identifying employees' top concerns about the use of robots in the workplace. According to the findings of the survey, which included 94 respondents, the main concerns are that robots may not know how to act in unexpected situations, humans will feel lonely if they work with robots instead of people, and robots will lack flexibility and mobility.

Findings obtained in this study can be used by decision makers and human resource managers with the aim to overcome the main concerns while implementing robots at workplace. Managers and human resource managers can create a positive working environment by educating employees on workplace robots using a wellplanned approach in the process of introducing technological solutions. Employees may not experience stress as a result of working with robots in this manner.

The number of respondents who participated in the research is one of the limitations of this study. The questionnaire received 94 responses. Furthermore, the questionnaire included closed questions and statements, without open questions in which respondents could express their own opinions and views. Besides that, the questionnaire did not include questions about respondents' occupation, industry, or geographic location so the conclusion cannot be generalized. It should also be noted that all respondents have no prior experience working with robots, so their responses are based solely on their beliefs and perceptions. Future research on this topic should include a higher number of respondents, and in addition to questionnaires, in future studies should be organized interviews with the aim to obtain deeper knowledge and information about robots at workplace. Furthermore, it would be important to conduct research in those organizations who have already introduced robots at the workplace and to examine and analyse real concerns and problems. In order to gain a better understanding and to address this study's limitation, it would be beneficial to include in a questionnaire a broader set of questions about respondents – work experience, job position, industry, geographic location, field of education.

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158



SINTEZA 2023

ADVANCED TECHNOLOGIES AND APPLICATIONS SESSION INVITED PAPER

SCRATCHPAD MEMORY UNIT IN HYBRID CONTROL-FLOW AND DATAFLOW ARCHITECTURES

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Abstract:

Dataflow architectures offer superior performance compared to control-flow architectures under certain conditions. This paper focuses on memory organization of a hybrid control-flow and dataflow architecture which guaranties that memory allocation can be accomplished in a predictable time. Mapping logical addresses into physical ones and accessing local memory in constant time is achieved using special address translation hardware. The memory organization is based on Buddy-system. It allows allocating arbitrary amounts of memory and prefetching data while it is being accessed by control-flow and dataflow hardware.

Keywords:

Dataflow architectures, Control-flow architectures, Scratchpad memory, Buddy-system.

INTRODUCTION

Real-time systems are a form of operating systems with a special purpose. They are employed when there are strict time constraints for job execution. A real-time system is considered to function correctly if and only if it returns a correct result respecting precisely defined time constraints.

In order to reliably determine the longest program execution time, many real-time systems are designed in such a manner, so that the memory access time is calculated as the time required to retrieve data from the main memory, assuming that the data will never be found in the cache memory. Some of the solutions involve the use of a cache entry locking mechanism. This ensures that the data, once loaded and locked in one cache entry to be written by one thread, cannot be changed by another thread. Another way to predict the maximal execution time is based on memory partitioning. In this case, statically sized partitions at boot time, and/or dynamic partitions can be used.

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Under certain circumstances, dataflow architectures are capable of executing a higher number of instructions per second compared to control-flow architectures [1, 2]. However, there are a lot of challenges. Programming dataflow architectures is considered to be reasonably harder compared to programming control-flow architectures [3]. Despite that, there are a lot of algorithms implemented for dataflow architectures [4], as well as methods to automate the translation of control-flow software into the dataflow [5, 6]. Placing both controlflow and dataflow components with shared memory at the same chip die requires special techniques [7-10], while it reduces the lifespan of a chip to the minimum lifespan of its components [11]. The applicability of the architecture is still being investigated [12]. Scheduling the execution of dataflow and control-flow jobs introduces more constraints compared to scheduling for control-flow architectures [13]. The granularity of jobs for which is justified to utilize dataflow hardware is still a research topic [14]. In short, there is a long way from an algorithm to the execution on a special chip [15].

This paper examines the allocation and the deallocation of memory, as well as local memory access mechanisms in hard real-time systems for the purpose of hybrid control-flow and dataflow processors.

2. PROBLEM DEFINITION

The aim of the work is to solve the problem of local memory fragmentation and memory access speed, so that this kind of memory model can be used in hybrid architectures. It is necessary to foresee:

- appropriate structures that store data on free and reserved memory blocks, such that an appropriate amount of free memory can be found in a predictable and relatively short time interval
- appropriate mechanisms that can access a local memory in a predictable time.

In addition to this, it is necessary to provide methods by which it is possible to load data into local memory before starting a program execution, if this is possible. Otherwise, it should be loaded during the execution.

3. EXISTING SOLUTIONS AND THEIR ANALYSIS

In recent decades, a lot of work has been done on solving the problem of cache memory partitioning in the case of multiprocessor systems. Most of the solutions represent either techniques for sharing resources by logically dividing cache memories [16-22] or techniques for assigning cache memory partitions in the case where a system supports private cache memories [23-26]. Unfortunately, various techniques introduce problems of unfairness [27], so-called trashing [28], and quality of service problems [29].

One of the solutions to the aforementioned problems is the allocation of cache partitions of requested sizes only in certain time intervals [30]. The justification for this approach lies in the following fact. If allocating a cache partition smaller than the partition size significantly reduces the efficiency of the system, the standard partition is not suitable. In order to avoid an unfair solution, in which some threads have the required amount of cache memory, while others have significantly less, the cache memory can be divided so that each thread has the required cache partition size only at certain intervals.

Another solution was proposed in the paper [29]. The main idea is to partition the set-associative cache, so that threads access always the same sets.

In each of the previously described cases, there is still the problem of fragmentation or the limitation of the amount of local memory that can be allocated to one thread. In the case of using fixed-length partitions, the problem of internal fragmentation occurs. If one thread was allowed to own exactly one partition, this would unnecessarily introduce a limit on the amount of memory that a thread can possess. If each thread was allowed to have a variable number of partitions, keeping an appropriate structure that would store data about occupied partitions for each thread would require additional memory, as well as the time needed to access this data.

4. ASSUMPTIONS

Before solving the problem of local memory organization, appropriate assumptions are listed:

it is possible to allocate any amount of free memory, which implies relatively little internal fragmentation

160

- it is possible to utilize the portion of a memory reserved for one thread, while freeing the space necessary for another thread
- it is possible to wait for the reservation of memory requested by one thread until the execution of another thread is finished, as long as the waiting time is predictable so that the use of memory blocks can be scheduled.

5. PROPOSED SOLUTION

This paper proposes a solution to the problem based on the so-called Buddy System [31] mechanism for storing data in memory. Figure 1 depicts an example logical organization of a reserved memory consisting of multiple blocks, each of them with the size 2ⁿ bytes, where n is a positive integer number. It goes without saying that each request for a certain amount of memory can be represented as a sum of requests for reserving memory blocks of size 2ⁿ, where each block is of a different size.



Figure 1 - Modeling a reserved memory as a sum of blocks.

Reserving memory for the requested sequence of blocks starts by checking whether the requested amount of memory is available in the system. Reserved memory consists of a sum of reserved blocks. We can also call them requested blocks. Then, for each of the blocks, the place in the local memory has to be found or freed. The following three cases can occur:

- there is a free block of the requested size
- there is a free larger block
- there is no block of sufficient size, but the total amount of free memory is larger than the requested block size.

In the case there is a free block of the requested size, one of such blocks must be declared as occupied, and the address of the beginning of the newly occupied block is written into the resulting vector of the memory reservation function. Otherwise, if a larger free block exists than the requested one, that block is divided into smaller ones, one of which is declared occupied.

In the case that there is no large enough block available in the system, but there is enough free space in the system, another function is called to move blocks in the local memory in such a way that the maximum amount of data that may be required to move in order to free up space for this block is predictable. First, a block of the required size is found, for which the cost of moving the occupied portion of data elsewhere is estimated to be minimal.

It should be noted that this does not mean that the highest percentage of the block is empty. For example, moving five blocks of the smallest size may require at most five moves of the amount of data of one of the smallest blocks. On the other hand, moving a block of size equal to four of the smallest blocks may involve moving a block of size equal to two smallest blocks, as well as moving another block of the smallest size, to make room for a block of size equal to four smallest blocks. Then it is necessary to move the block for which the memory is reserved, i.e. another moving of the size equal to four smallest blocks is needed. Moving a block of the size equal to two smallest blocks, it is again necessary to make room for it, which may involve moving one block of the smallest size, and then moving a block for which the memory is freed, ie. moving the block of size equal to two smallest blocks. In the described way, it would be necessary to move eight blocks of the smallest size, which is significantly more than moving five smallest blocks. Therefore, the cost of moving five blocks of the smallest size could be assigned the number five, while the cost of moving a block of size equal to four blocks of the smallest size could be assigned the number eight.

After finding the block that is found to have the lowest moving cost, it is necessary to recursively call the same function to free space in the local memory for each of blocks contained in it by move contained blocks. The function for freeing the local memory processes the vector passed to the function as an input parameter, and is responsible for freeing a memory for each of the blocks corresponding to the components of this vector. If, by freeing a memory occupied by any of the blocks, it is determined that the adjacent block of the same size is empty with which it can form a bigger block, it is necessary to declare these two blocks as one single free block of twice the size. Again, the resulting bigger free block has an empty neighborhood block of the same size, with which it can form a bigger block, these two blocks must be merged again in order to become one free block. This procedure is repeated until the previously described condition is not met.

In order to support access to a memory with such organization, it was necessary to provide the mechanism for mapping generated logical addresses into the physical ones. Each thread accesses its local memory as if it was a contiguous memory of certain size. Following actions need to be performed in order to enable mapping generated addresses into physical ones:

- determine which block the data belongs to
- determine the displacement relative to the beginning of the block.

Block *i*, where *i* is a positive integer, is exactly twice the size of block i+1. If the heaviest bit of the generated address is set to 1, block 0 is accessed. In this case, the remaining bits of the generated address are taken as an offset relative to the beginning of that block. In the case the bit of the highest weight of the generated address is set to 0, the next bit is observed. If it is set to 1, block 1 is accessed. In that case, the remaining bits of the generated address are used to determine the displacement. This way, it is determined which block needs to be accessed, as well as the offset relative to the beginning of that block. In general, the first bit of the generated address that is found to be set (equal to 1) determines the block address, and the bits to the right of this bit represent the offset.

This way, it is possible to transform the generated address into the physical address without using an adder, that is, only by choosing which bits should be taken from the block address, and which bits should be taken from the generated address. The process of transforming the generated into physical addresses is depicted in Figure 2. The block 0 size is equivalent to one half of the memory size, and, as such, can be placed either in the first half, or in the second half of the memory. Therefore, the starting address of the block has only 1 bit that is important, while other bits are equal to 0, and can therefore be ignored (don't need to be stored). Similarly, block 1 address contains only the first 2 important bits, while the rest of the bits are considered to be equal to 0. In general, block i address has exactly the first i+1 important bits. In order to determine the physical address, these important bits are taken from the block starting address, while the remaining bits are taken from the generated address, as they represent the offset from the beginning of the block.



Figure 2 - The process of transforming logical into physical addresses.

Once the memory has been reserved for a thread, it is possible to load the data required by a thread into the local memory before the execution of the thread. It is also possible to load the data into one of the obtained memory blocks, while the remaining blocks have not been freed.

6. MEMORY RESERVATION ANALYSIS

In this chapter, an analysis of the proposed solution for reserving a memory is given, with the aim of enabling the proper configuration of a system, so that the internal fragmentation is as small as possible, as well as the time required to provide the required amount of data. First, the theorem and the corresponding proof are presented.

Theorem 1: In order to provide the space for a block whose size is equal to 2^n smallest data blocks, it is necessary to move, in the worst-case, $n*2^{n-1}$ smallest data blocks.

Proof: First, we can assume that the total amount of free memory is always greater than the requested amount of memory. Otherwise, reserving the requested amount of memory is not possible.

Let us assume that the value of the number n is equal to 1, and that the smallest block size is equal to 1 byte.

If we want to provide the space for 2^1 bytes, it is in the worst case necessary to move 1 byte from one place in the memory to another. If we set the value of the number *n* to 1 in the formula given in the theorem, we get the same result.

By applying mathematical induction, if we assume that the formula given in the theorem is correct for some arbitrary value of the number n, we can derive how many of the smallest data blocks need to be moved in the event that the required amount of memory is 2^{n+1} bytes.

It is known that it is necessary to move, in the worst case, $n \star 2^{n-1}$ smallest data blocks, in order to make room for 2^n data blocks.

In addition to this, in the worst case, it is necessary to move another block of the size equal to the size of 2^n smallest data blocks, in order to provide space for a data block of size equal to the size of 2^{n+1} smallest data blocks.

In order to provide space for 2^n data blocks, it is necessary to move, in the worst case, $n \star 2^{n-1}$ smallest data blocks.

Summing up the necessary moves of the smallest data blocks, we obtain the result of Equation 1.

$$2^{n}+n*2^{n-1}+n*2^{n-1}=2^{n}+n*2^{n}=(n+1)*2^{n}$$
(1)

Equation 1 - Number of blocks needed to be moved in the worst case.

As we have shown that the theorem is true in the case the value of the number n is set to 1, and then, starting from the assumption that it is true for some value of the number n, that it is also true for the value n+1, it has been proven that the theorem is true.

Therefore, the size of the smallest block should be chosen, so that the system has the best performance. The optimal value of the size of the smallest block can be determined empirically, having in mind the internal fragmentation and the control logic needed for handling addresses of blocks.

7. RESULTS

By analyzing the proposed solution, it was determined that, in order to provide contiguous space for the 2^n smallest data blocks, in the worst case $n*2^{n-1}$ smallest data blocks must be moved. The simulator implemented in the programming language C++ enables monitoring of block movement when freeing local memory. The simulation results confirm that the number of necessary moves of smallest blocks cannot exceed the value given in a Theorem 1. As an example, a system was implemented for which the ratio of the number of bytes that need to be moved and the required amount of local memory in the worst case is four, which corresponds to the value of the number n set to eight in the formula. It should be noted that this factor is proportional to the number *n*.

8. CONCLUSION

By analyzing amounts of memory and hardware resources needed to store data structures intended for data access and implement data access in hardware, as well as by comparing the data access times, from all the analyzed systems, the Buddy System was chosen due to the deterministic time needed for memory allocation and its simplicity. Appropriate C++ simulator was implemented, proving the validity of theoretical analysis.

Bearing in mind that the time required to access the main memory of a computer is far greater than the time required to access the local memory (e.g. cache or scratchpad), it can be considered that the proposed solution effectively solves the problem of fragmentation and enables sharing the local memory between control-flow and dataflow hardware. Further research directions relate to determining the optimal relationship between the minimal block size and the amount of memory that can be reserved, so that the access hardware is relatively small, as well as internal fragmentation, while the size of the largest block that can be reserved does not limit the execution of high performance algorithms.

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164

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ADVANCED TECHNOLOGIES AND APPLICATIONS SESSION

APPLICATION OF THE 3D GEOGEBRA CALCULATOR FOR TEACHING AND LEARNING STEREOMETRY

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Abstract:

In this paper, we demonstrate how the 3D geometrical models can be generated using the dynamic mathematical software GeoGebra, and how can these models be used for teaching and learning Geometry, that is, stereometry.

Three geometrical problems are presented, processed using the 3D GeoGebra tools, and their features and possible applications are discussed. Special attention is paid to the ways to manipulate the presented materials, and also to the different possibilities for displaying and observing the objects generated in this way.

All the GeoGebra materials prepared for this paper can switch to a special mode for working with 3D glasses, and one section of the paper is dedicated to this GeoGeobra feature and the possibility of creating a real 3D environment.

The benefits of the application of these 3D models are discussed, and future remarks are given, considering the possible ways for using the 3D GeoGebra Calculator.

Keywords:

3D GeoGebra Calculator, Geometry, 3D Models, Stereometry, 3D Glasses.

INTRODUCTION

Geometry is one of the fundamental fields of mathematics. Mastering geometry knowledge and skills has always been a challenge for students. Imagining objects, especially in 3D space, establishing relationships between them, and solving geometric problems can sometimes be very demanding because they require simultaneous work with multiple representations, geometric, graphic, and algebraic.

When considering the process of learning geometry, the van Hiele Model of geometric thinking is mostly used. This model includes five levels through which students pass during the learning process, in order to gradually acquire knowledge and understanding of geometric concepts [1]. Taking this into account, the different approaches to teaching and learning geometry were explored, mostly the manipulative approach and the technology-based one [2]. It was confirmed that the technologybased approach had the best effects on students' achievements.

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e-mail: tsekulicvts@gmail.com Over the years, many different software were developed for the purpose of teaching and learning mathematics, especially geometry. The GeoGebra software and its tools for 2D, and later for 3D geometry and augmented reality stood out as one of the best for educational purposes. There are many researches and reports about the successful implementation of GeoGebra and its 3D geometry and augmented reality modules [3], [4], [5].

Concerning all the results from previous research, we have chosen GeoGebra software for developing materials in 3D and for 3D glasses which were applied as support for teaching stereometry and for solving problems in this field.

2. CREATING GEOMETRICAL MODELS USING THE 3D GEOGEBRA CALCULATOR

GeoGebra is dynamic mathematical software, designed for application in mathematics and sciences. It is open-source software, easy to use, but powerful concerning the possibilities of its tools.

GeoGebra has several modules, such as Graphing Calculator (for graphing functions, investigating equations, and plotting data), Geometry (for constructing circles, angles, transformations, etc.), CAS Calculator (for solving equations, expanding and factoring expressions, finding derivatives and integrals), and 3D Calculator (for graphing 3D functions, plotting surfaces and doing 3D geometry). All modules are available for use online or download, and all of them can work on all platforms (Windows, IOS, Linux, Android).

3D Calculator is especially interesting for application when teaching and learning stereometry. It is equipped with multiple tools, such as the tool for creating planes (using three points, perpendicular or parallel plane), intersecting surfaces, drawing prisms, cones, cubes, spheres, etc. All the tools mentioned above are located in the upper left corner of the 3D Calculator window, Figure 1.

In the upper right corner of the window, there are more tools, for choosing the type of projection, rotation, etc., Figure 1.

We used the GeoGebra 3D Calculator for creating materials that can be applied as additional help for solving problems in stereometry. For each problem, we have made 3D model, available for public use on GeoGebra's official website.



Figure 1 – The window of the GeoGebra 3D Calculator.
Problem 1:

A hexahedron $ABCDA_1B_1C_1D$ of edges a is given. If point S is the middle point of the edge BB_1 , determine the area of intersection of the prism and the plane containing the vertices A_1 and C_1 and the given point S.

The 3D GeoGebra model of the hexahedron from Problem 1 is represented in Figure 2.

Using this 3D representation the students can see the precise drawing of the geometrical object and therefore, they can gain better insight into the problem and its solution. But, a far more important and valuable is the possibility of a 3D GeoGebra Calculator to manipulate the 3D object, meaning, it can be rotated and observed from different points of view, Figure 3.

The rotation of the 3D object and observing it from different points of view can be easily achieved by simply "dragging" the object using a pointer. This feature of GeoGebra, especially the 3D Calculator is the greatest possible help students can get when learning stereometry. By carefully examining the difficulties students face in geometry, it is determined that the biggest problem is the impossibility of imagining the space and presenting (sketching) it in the best way in order to understand the problem. The material for Problem 1 is available online, on the official GeoGebra website [6].



Figure 2 – 3D Representation of Problem 1.



Figure 3 – Different points of view for Problem 1.

Problem 2:

A regular three-sided equilateral prism $ABCA_1B_1C_1$, edge a is given. If point E is the middle point of the edge A_1C_1 , and point F is the middle point of the edge B_1C_1 , determine the cross-sectional area of the prism and the plane containing the segment EF and the prisms' edge AB.

As for the previous problem, the 3D Calculator was used for representing a 3D object from Problem 2. Some of the different views of the object are presented in Figure 4.

The material for Problem 2 is also available online, on the official GeoGebra website [7].

Problem 3:

Determine the intersection of a regular four-sided prism and a plane parallel to its base.

For the purpose of this problem, we used the GeoGebra tool called *Slider*, in order to enable additional "move-ment" of the intersection plane, Figure 5.

By moving the slider *b* from the upper left corner of the GeoGebra window, the plane will move parallel to the base of the prism, allowing students to see its different positions, Figure 6.



Figure 4 - Different points of view for Problem 2.



Figure 5 – Intersection of the prism and plane for Problem 3.



Figure 6 – Different positions of the plane for Problem 3.

The material for Problem 3 is available on the official GeoGebra website [8].

From the problems presented above it can be seen that the 3D representation of the geometrical objects is easy to create by using the 3D GeoGebra Calculator. The benefits of such materials can be various, and one of the important ones is the possibility for students to "see" the 3D space to manipulate it.

3. THE GEOGEBRA MODE FOR WORKING WITH 3D GLASSES

GeoGebra 3D Calculator has special tools for transforming 3D drawings into those adapted for the application of specialized 3D glasses. The tools for choosing a projection for 3D glasses are positioned in the upper right corner of the GeoGebra window, Figure 7.

By using the tool where the glasses are marked, GeoGebra automatically transforms the existing drawing into the one adapted for 3D glasses, Figure 8.



Figure 7 - GeoGebra tools for choosing projection type and 3D glasses.



Figure 8 – Transformation of 3D object a) into an adapted object for 3D glasses b).

When using the 3D glasses on objects transformed in this way, the insight into "depth" is enabled and a complete sense of space is achieved. The possibility of rotating the objects and observing them from different points of view is also available. The tool for adapting 3D objects for 3D glasses is applicable to all objects created using GeoGebra 3D Calculator. All problems presented in this paper and their corresponding materials on GeoGebra's official website can be adapted for 3D glasses by using the above-mentioned tool.

4. DISCUSSION AND FUTURE REMARKS

The materials presented in the previous sections of the paper can be used for teaching geometry (stereometry) at all levels of mathematics education. The benefits of this way of representing geometric objects are multiple.

First, using GeoGebra, it is possible to be much more precise, which contributes to a simpler insight into the possible solutions to the geometric problems. The possibility for multiple representations (algebraic, numerical, graphical, dynamical) that GeoGebra offers especially contributes to analyzing and solving problems.

The 3D Calculator tools for creating 3D objects are immeasurable and help students who have a problem with imagining space and objects in it. The possibility to manipulate objects and observe them from different points of view can induce a higher level of understanding of space and relations within it.

Adaptation of 3D objects for using 3D glasses is a particularly good opportunity that GeoGebra provides. It is possible to observe objects in real 3D space, including depth. Very important to mention is that in this case there are no major requirements regarding technical equipment, GeoGebra is open-source software and glasses are available to everyone for their symbolic value.

Future remarks include further upgrades and application of GeoGebra materials developed in the 3D Calculator. It is important to note that GeoGebra has a module for augmented reality which is more sophisticated and offers even more possibilities for working in 3D surroundings.

5. CONCLUSION

Technology and modern software tools have proven themselves to be of great help to teachers and students to enable a better understanding of mathematical concepts. This is especially important concerning teaching geometry and stereometry where students have to develop geometric thinking and the skills to imagine the 3D space and relations between objects within it.

GeoGebra software and its modules and tools proved to be very effective for educational purposes. The 3D modules for creating 3D objects have more than enough various tools for drawing 3D objects and possibilities for their display and manipulation.

Also, the option for adaptation of 3D GeoGebra materials for the use of 3D glasses adds one more useful opportunity for creating an environment that can contribute to deeper understanding and better visualizing of 3D space. Further application of 3D GeoGebra modules goes toward the development of more sophisticated 3D materials combined with 3D glasses and the use of augmented reality.

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ADVANCED TECHNOLOGIES AND APPLICATIONS SESSION

MODELING INTERNET TRAFFIC PACKET LENGTH USING PROBDISTID: A CASE STUDY

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Abstract:

In this study, we apply the ProbDistID tool, a user-friendly tool based on nonlinear regression, designed for fitting probability distributions and estimating their parameters, to model internet traffic packet length using a real-world internet traffic dataset. The tool requires no a priori knowledge of input data, making it suitable for real-time fitting recognition and for data mining tasks. Our primary objectives in this case study are to identify distributions that offer the best fit for internet traffic datasets. We utilized our tool to fit and estimate parameters for eight cumulative density functions (CDFs). The fitting results are presented using utilized several model selection methods and goodness-of-fit tests to determine the most appropriate distribution model. The case study indicate that the Generalized Extreme Value (GEV) and Pareto distributions provide the most accurate fit. Our findings are presented graphically and in tabular form, demonstrating the effectiveness of ProbDistID and its potential applicability across various fields, including data mining tasks.

Keywords:

Data Mining, Internet Traffic, Nonlinear Regression, Cumulative Distribution Function, Model Selection.

INTRODUCTION

Nonlinear regression [1] (NR) is a valuable statistical method for understanding and modelling data and processes in various fields. Although there are other approaches available, such as linear regression, nonlinear regression has proven to be particularly important due to its ability to model complex relationships between variables. In this paper, we focus on the application of nonlinear regression in several domains, including fading in wireless systems [2], [3], medical signal analysis [4], [5], computer vision [6], internet traffic modelling [7], [8], and other diverse examples.

Despite the rise of numerous machine learning (ML) and artificial intelligence (AI) techniques, such as deep learning, support vector machines, and decision trees, nonlinear regression remains a relevant and valuable tool for data modelling. Its continued importance can be attributed to its flexibility and robustness in handling complex relationships and noisy data.

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e-mail: dragisa.miljkovic@pr.ac.rs In this study, we utilize ProbDistID, a user-friendly tool with a graphical user interface (GUI), designed for fitting probability distributions and their parameters. The underlying algorithm for ProbDistID, which is based on the Levenberg-Marquardt nonlinear regression algorithm [9], [10], has already been tested and published in a previous paper. This research serves as a continuation of our efforts to apply nonlinear regression to fit data in real-world processes using ProbDistID.

The primary objectives of this study are to identify the best modelling distribution for internet traffic and to analyse the applicability of eight appropriate cumulative density functions (CDFs) for fitting experimental traffic data. Our contributions include analysing the selected CDFs for fitting the experimental traffic data (traces) and determining the best-fitting distribution to accurately represent internet traffic patterns in the given context.

2. PROBDISTID: A BRIEF OVERVIEW

ProbDistID¹ is a web-based tool specifically developed to simplify the process of identifying probability distributions and their parameters for user-selected scenarios. It streamlines the process of selecting appropriate probability distributions and estimating their parameters, making it a valuable asset for data-driven decisionmaking and data mining tasks across various domains. The underlying algorithm description and pseudocode for ProbDistID can be found in reference [1]. Built upon previous work [2], ProbDistID presents an enhanced version of the approach, which was validated in a prior study using a large set of 38,400 randomly generated signals with five different probability distributions commonly employed to model wireless fading, such as Gamma, Rayleigh, Rician, Nakagami-m, and Weibull.

Key upgrades in the new version include the development of a user-friendly GUI interface (Figure 1), replacing the previous CLI tool; the implementation of the entire algorithm in R as opposed to MATLAB for signal generation; the addition of more probability distributions (currently 14, with support for more in the pipeline), and the incorporation of more model selection criteria and goodness-of-fit tests (also being continually enhanced).

ProbDistID offers a range of capabilities, such as signal generation using any of the supported distributions with user-selected parameter values, signal recognition, and batch signal recognition of a set of inputs (allowing users to upload data in RData, CSV, JSON, XML, and plain text formats). It also provides a tabular presentation of fitting results, making it easier for users to understand and interpret the results. Additionally, the tool provides a tabular representation of the estimated parameters, which assist users in selecting the best-fitting model for their data.

A case study demonstrates the effectiveness and utility of ProbDistID in describing internet traffic, highlighting its potential for application in a wide array of fields and scenarios.

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Figure 1 - ProbDistID Graphical User Interface.

¹ Available online: https://x9u9lx-despot.shinyapps.io/ProbDistID/

3. DATASET: MAWI WORKING GROUP TRAFFIC ARCHIVE

In this study, we utilized the MAWI Working Group Traffic Archive [11], which is a collaborative project between Japanese network research and academic i nstitutions. Their goal is to analyse the performance of networks and networking protocols within Japan's wide area networks. The dataset is made up of daily traces taken at the transit link of WIDE to the upstream ISP, as a component of the "Day in the Life of the Internet" project. This link functions at a capacity of 1 Gbps.

We selected the DumpFile: 202304301400.pcap [12], generated between Sun Apr 30 14:00:00 2023 and Sun Apr 30 14:15:00 2023. The file contains 53,857,184 packets captured during a 15-minute period, with a size of 4 GB and an average rate of 306.45 Mbps. We used the tshark network protocol analyser for data pre-processing and analysis. Tshark is a versatile tool that allows users to capture packet data from a live network or read packets from a previously saved capture file, decoding and printing the packet information or writing the packets to a file. In our study, we employed tshark to filter out Ethernet packages, limiting the packet sizes in our dataset to a maximum of 1500 Bytes, which corresponds to the Maximum Transmission Unit (MTU) size.

This case study focuses on modelling internet traffic packet length using the MAWI Working Group Traffic Archive dataset. However, the methodology can be extended to live packet capturing and fitting distributions with real-time data. This information is valuable for various applications, including:

- Network congestion prediction [13]: By understanding the distribution of packet lengths, network administrators can anticipate congestion and take appropriate measures to prevent bottlenecks.
- Network performance optimization [14]: Analyzing the characteristics of the traffic can help in adjusting parameters such as buffer sizes and transmission rates to optimize network performance.
- Anomaly detection and network security [7]: Comparing real-time traffic with expected patterns based on historical data can aid in detecting anomalies or potential attacks on the network, thereby enhancing its security.

4. METHODOLOGY

Our approach is based on the rationale that Prob-DistID provides an efficient and user-friendly way to identify the best-fitting probability distribution for a given dataset.

In the initial phase, we examined packet capture files using GUI tools such as Wireshark. However, we found that data analysis tools like the R programming language offered more flexibility and efficiency. To process the data more rapidly, we employed the tshark command-line tool. We used tshark commands to extract the lengths of all Ethernet frames. The resulting file is very large (200MB), but a significant amount of data in it is redundant, there are several million rows, but only 1500 possible lengths. To improve efficiency, we summarized the data as frequencies of occurrences of packet data lengths.

Based on the literature [7], [8], [14], we selected the following probability distributions for fitting: Beta, Exponential, Gamma, Generalized extreme value (GEV), Log-normal, Nakagami, Pareto, and Weibull. We then used the data obtained in the previous step as input in ProbDistID tool. Subsequently, we calculated the discrete cumulative distribution function (DCDF) to obtain the cumulative distribution of packet sizes, and fitted the distribution models accordingly.

In order to determine the best-fitting model for our data, we employed several model selection methods and goodness-of-fit tests. These include: Akaike Information Criterion (AIC) [15], [16], a that balances the goodness-offit with the complexity of the model, Bayesian Information Criterion (BIC), similar to AIC, but with a stronger penalty for model complexity, Residual Sum of Squares (RSS), Root Mean Square Error (RMSE), R-squared, and Adjusted R-squared (a modified version of R-squared that adjusts for the number of predictors in the model). By applying these methods and tests, we were able to identify the most appropriate distribution model for the internet traffic packet length dataset.

5. RESULTS AND DISCUSSION

In this section, we present a comprehensive analysis of the results obtained from our application of Prob-DistID to model internet traffic packet length. We provide visual representations in the form of plots for the fitted distributions, as well as detailed tabular summaries of the values for model selection and goodness-of-fit tests, along with the fitted parameters.

174

Figure 2 illustrates the cumulative distribution of packet lengths and bytes in the original dataset, with a focus on packets up to 1500 bytes (Ethernet packages). This figure offers a clear visualization of the distribution of packet lengths and bytes, revealing the presence of very large and very small packets as the spike points. This is a typical characteristic of Internet traffic, referred to as Internet Mix (IMIX) [17], [18].

To ensure readability and avoid cluttering the plots, we present the fitting results in two separate figures. Figure 3 showcases the results of fitting the GEV, Nakagami, Gamma, and Beta distributions, while Figure 4 offers a comparison between the Weibull and Lognormal distributions. These two figures enable a clear evaluation of the eight distributions' performance in fitting the data.



Figure 2 - Cumulative Distribution of Packet Sizes and Bytes.



Figure 3 - Fitting of GEV, Nakagami, Gamma, and Beta distributions.

Complementing the visual representations, we provide detailed tables that encapsulate our findings. Table 1 lists the parameter values of the fitted distributions. Table 2 presents the values of model selection methods and goodness-of-fit tests, such as AIC and BIC criteria, where lower values indicate better fit. From these results, it becomes evident that the GEV and Pareto distributions provide the best fit.

		1	
Distribution	Parameter 1	Parameter 2	Parameter 3
Pareto	shape = 0.0215	scale = 0.5265	
Weibull	shape = 0.4997	scale 0.1927	
Exponential	rate = 4.057		
Log-normal	meanlog = 0.023	sdlog = 1.966	
Nakagami	shape = 0.2914	scale = 0.1352	
GEV	shape = 2.23463	scale = 0.03438	location = 0.0478
Gamma	shape = 0.3319	scale = 1.0104	
Beta	shape1 = 0.1941	shape2 = 0.5430	

Table 1 - Fitted distribution parameters.

Table 2 - Criteria for model selection.

Distribution	AIC	BIC	RSS	RMSE	R squared	Adj. R squared
Pareto	-242.7	-234.9	0.48	0.069	0.87	0.867
Weibull	-212.54	-204.73	0.65	0.081	0.824	0.82
Exponential	-111.8	-106.6	1.83	0.135	0.51	0.5
Log-normal	-221.9	-214	0.59	0.077	0.84	0.836
Nakagami	-203	-195	0.72	0.085	0.807	0.803
GEV	-250.7	-240.2	0.44	0.066	0.882	0.878
Gamma	-206.4	-198.6	0.69	0.083	0.813	0.809
Beta	-205.9	-198.0	0.7	0.085	0.811	0.808

The IMIX phenomenon also explains why the Generalized Extreme Value (GEV) and Pareto distributions offer the most accurate fit. The Pareto distribution, often referred to as the 80:20 rule, suggests that 80% of outcomes result from 20% of causes. In the context of Internet traffic, this concept is particularly relevant. The GEV distribution is commonly employed to model extreme events, such as the largest or smallest values in a dataset. One reason why the GEV distribution fits well with the cumulative distribution of internet packet sizes is the heavy-tailed behaviour exhibited by the packet size distribution. This means there is a relatively high probability of observing numerous small and large packet sizes, which can be considered extreme events. Our study offers valuable insights into the statistical modelling of internet traffic, paving the way for future experimentation and analysis. Nonetheless, further research is necessary to explore this topic in greater depth.

6. CONCLUSION

In this paper, we have presented a show case of using the ProbDistID tool to fit cumulative probability distributions to a real-world internet traffic dataset. In our experiment, eight probability distributions were used to model a large dataset of internet traffic data, with a focus on the packet lengths. The obtained results indicate that the Generalized Extreme Value (GEV) and Pareto distributions offer the best fit for the data. The presented approach may have practical usage in computer networks, as network administrators can utilize similar tools to get better insights in system throughput, load, and security threats.

However, it is important to note that this was a limited experiment, and the best-fitting distribution models we identified might not necessarily be the optimal models for other datasets. Further research is needed, preferably using even larger datasets, to validate and extend these findings.

The results add to the previously successful application of the tool for fading in telecommunications, and shows that the presented tool can be used in numerous fields. In the pipeline, as ProbDistID tool continues to evolve, the authors plan to apply the tool to real-time internet traffic analysis and to explore its application in other domains.

7. ACKNOWLEDGEMENTS

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APPLIED INFORMATION TECHNOLOGY SESSION

ADVANCED TECHNOLOGIES AS A FRAMEWORK FOR SUSTAINABLE MARKETING CAMPAIGNS (AI APPLICATION IN NEUROMARKETING)

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Abstract:

As the business landscape evolves into a more digital environment, traditional marketing methods are no longer sufficient for companies to stay competitive. In order to gain an advantage in the market, businesses must integrate the latest technologies, including AI. Neuromarketing has benefitted greatly from AI-powered tools, providing marketers with valuable insights into consumer behaviour, emotions, and preferences. With this information, they can create targeted and sustainable marketing campaigns that generate long-term value for the brand while minimizing negative environmental impacts. This paper delves into the potential of AI in neuromarketing as a framework for sustainable marketing campaigns. It examines the challenges and benefits of using AI in marketing, showcasing successful campaigns that have leveraged AI-powered tools to create sustainable strategies. Furthermore, the paper emphasizes the importance of measuring customer engagement, which plays a crucial role in the creation of effective marketing campaigns. The present study utilized AI technologies such as video processing to analyse the sentiment of stimuli presented in university enrolment campaigns over a two-year period. By identifying the age, gender, and sentiment of customers, we gained insights into their behaviour and preferences. Our research showed that incorporating a clear "call to action" message can significantly improve the effectiveness of marketing campaigns. Overall, our study demonstrates the potential of AI technologies in enhancing customer engagement measurement and optimizing marketing strategies for sustainable campaigns.

Keywords:

Ai, Advanced Technologies, Neuromarketing, Marketing Management, Sustainable Marketing Campaigns.

INTRODUCTION

With the rise of digital technologies, the marketing landscape has experienced a significant transformation. The emergence of digital technologies has brought about a significant transformation in the marketing industry, leading businesses to explore new approaches to gain a competitive edge. One of the popular technologies that have gained traction in the marketing field is Artificial Intelligence (AI). AI-powered tools have proven to be highly effective in neuromarketing, offering marketers valuable insights into consumer behaviour, emotions, preferences, and customer engagement measurement [1], [2].

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e-mail: tpapic@singidunum.ac.rs With the aim to measure the impact on the industry brands, the effectiveness of marketing campaigns is now being evaluated at their sustainability level. Sustainable marketing campaigns aim to create long-term value for the brands and clients, while minimizing the negative impact on the environment [3]. By incorporating AI in the field of marketing and neuromarketing, marketers can create campaigns that are not only more efficient but also more sustainable. The paper explores the potential of advanced technologies, specifically AI in neuromarketing, as a framework for sustainable marketing campaigns [4]. By integrating AI-powered tools into marketing strategies, brands can gain deeper insights into consumer behaviour and preferences [5] - [7].

The benefits of using AI in marketing will be discussed, along with examples of successful marketing campaigns for student enrolment purposes. Since the focus of the present research is a comparison of the marketing campaigns with and without "call to action" messages, L. Arvanitidis found in his study that incorporating a clear "call to action" message can improve the effectiveness of marketing campaigns that use AI-powered neuromarketing techniques [8]. By the time and rise of digital technologies, AI has become an integral and important part of marketing strategies, especially in the field of neuromarketing [9]. AI-powered tools shown effective in enabling marketers to gain valuable insights into consumer sentiment, behaviour, emotions, and preferences, with a focus on customer engagement [10], [11]. The effectiveness of marketing campaigns is not just measured by their impact on the brand but also by the campaign's sustainability [12] - [14].

The present study focuses on the utilization of AI technologies, particularly video processing, to analyse the sentiment of stimuli presented in university enrolment campaigns over a two-year period. By employing these technologies to identify customers' age, gender, and sentiment, the study aims to gain valuable insights into consumer behaviour and preferences. The findings of this study suggest that incorporating a clear "call to action" message significantly improves the effectiveness of marketing campaigns [9], [10]. The implications of these findings for future research and marketing practice will be discussed in the concluding section. The study aimed to gain valuable insights into consumer behaviour and preferences by identifying customers' age, gender, and sentiment. Overall, this study aims to demonstrate the potential of AI technologies in enhancing customer engagement measurement and optimizing marketing strategies for sustainable campaigns.

2. METHODOLOGY

The application of the advanced technologies and neuromarketing techniques was tested using an innovative hardware and software system called MojoAI during a two-day education fair in Novi Sad in 2023. The MojoAI platform (created by Mojo AI Media Technologies) displayed animated content (text, graphics, images) and anonymously recorded visitors' reactions, determining the age cohort, sentiment (positive, neutral, negative), and gender. The MojoAI platform is fully compliant with the Personal Data Protection Law and GDPR. The entire analysis takes place on the device using localized analytics containing artificial intelligence, and the application immediately anonymizes and deletes video recordings after analysis.

The accuracy of the analytics is achieved within, where the network is trained on-site to learn and recognize whether one person returns multiple times in a specific time without recording personal data. To achieve this, a sophisticated anonymization system is used, where the facial anatomy is kept as a mathematical record that cannot reconstruct the face, and these anonymized data are used for further statistical analysis of visitor reactions.

In the present study, the AI method being used is called "on-device learning" or "edge AI." Instead of training the AI model in a central location, it's trained directly on the device itself (in this case, a tablet). The model can learn and recognize patterns in the data without transmitting any personal information to a central server. It allows for real-time processing and analysis of data while still protecting the privacy of the individuals being analysed.

To further protect visitors' privacy, an anonymization system is used. This system likely involves face recognition, feature extraction, and encoding techniques to create a mathematical representation of facial features that can be used for analysis without revealing personal information. The AI features and programs that are trained on-site to recognize and track visitors without recording personal data include: 1. Deep Learning: This type of AI uses artificial neural networks to learn from data, allowing the system to recognize patterns and make predictions based on collected data. 2. Computer Vision: This AI technology enables machines to recognize and interpret images and video, which is useful for analysing facial features and tracking visitors without recording personal data. 3. Convolutional Neural Networks (CNNs): A type of neural network commonly used for image classification and recognition, which can be used to recognize facial features and track visitors without recording personal data. 4. Anonymization Techniques: Techniques such as differential privacy and homomorphic encryption are used to protect visitors' privacy and ensure that collected data cannot be linked to specific individuals. 5. Face Recognition Algorithms: These algorithms are used to identify and track visitors without recording personal data, helping to protect their privacy.

The data collection methodology involved activating the hardware part of the platform (tablet displaying content at the Singidunum University booth at the fair), displaying stimuli (enrolment campaigns for selected study programs in 2021 and 2023), registering booth visitors within a distance of 2.5 meters from the tablet, analysing sentiment in real-time, and creating statistics according to age cohorts and gender.

During the two-day fair, the application recorded 1281 targeted displays and 600 booth visitors, of which 60% were male, and 40% female.

3. RESULTS

Figure 1 shows the velocity of viewer engagement. In the context of neuromarketing, velocity in viewer engagement refers to the speed and intensity with which a viewer responds to a marketing stimulus, such as an advertisement or a product display. In terms of sentiment analysis, velocity can be used to indicate the strength of positive or negative reactions to a stimulus. For example, if a viewer's sentiment shifts quickly from positive to negative during a commercial, this could indicate a strong negative response.

Figure 2 shows examples of the enrolment campaigns for the study years 2023 (a) and 2021 (b). The results showed that the velocity of the engaged visitors from the cohort 18-24 years for campaign 21 performed with higher engagement compared to campaign 23, especially in the segment which contains a call to action.

The Velocity for campaign 2021 for cohort 18-24 was 58,37% , while the velocity for campaign 2023 for cohort 18-24 was 38,71%.



Figure 1 – Velocity of the viewer engagement in different campaigns.



Figure 2 – Example of the enrolment campaign for the study year 2023 (a) and 2021 (b).

182

4. DISCUSSION

The study aimed to test the effectiveness of advanced neuromarketing techniques in marketing campaigns using innovative hardware and software solutions. The study utilized MojoAI, a platform that uses AI to analyse visitor reactions to marketing stimuli in real-time while also ensuring GDPR compliance and data privacy. The platform was tested during a two-day education fair in Novi Sad, 2023. The study demonstrated the effectiveness of MojoAI in collecting anonymous data on visitor reactions, including sentiment, age, and gender.

Based on the data presented, it can be concluded that the enrolment campaign for 2021 performed better than the campaign for 2023 in terms of the velocity of engaged visitors, particularly in the cohort of visitors aged 18-24. The velocity of engaged visitors for the 2021 campaign in this cohort was 58.37%, while it was 38.71% for the 2023 campaign. This suggests that the strategies used in the 2021 campaign were more effective in engaging visitors and eliciting a response, particularly with a call to action. It would be beneficial to further analyse the specific elements and strategies used in the 2021 campaign that contributed to its success and compare them to the 2023 campaign to identify areas for improvement. The results of the study indicated that the velocity of engagement for campaign 21 was higher than campaign 23, especially in the segment with a call to action, for cohorts 18-24. This finding suggests that targeted marketing campaigns with a clear call to action are more effective in engaging visitors in this age group.

The importance of effective CTA strategies in marketing campaigns has been previously emphasized in the literature [15]. Our findings support these claims, particularly for the younger demographic. Furthermore, the effectiveness of neuromarketing techniques in generating insights into viewer engagement and behaviour has been demonstrated in previous studies [6,7,16]. Our study builds on this research by demonstrating the potential of the MojoAI platform in providing real-time insights. Additionally, the use of AI and anonymization systems in marketing research has been suggested in previous studies [17-20] for privacy protection and accurate data analysis.

5. CONCLUSION

Overall, the use of advanced technologies like MojoAI in marketing campaigns has significant potential in enhancing marketing efforts while also ensuring data privacy and compliance with data protection laws. These findings provide valuable insights for businesses seeking to create more sustainable marketing campaigns that engage their target audience effectively. Further research can investigate the effectiveness of these advanced techniques in other settings and explore additional factors that influence visitor engagement in marketing campaigns. The study highlights the importance of incorporating call-to-action (CTA) elements in enrolment campaigns to engage young adults. The study also demonstrated the potential of neuromarketing techniques, particularly MojoAI, in generating valuable insights into viewer engagement and behaviour in realtime. Advanced technologies such as AI and anonymization systems can help protect privacy while providing accurate data for statistical analysis of visitor reactions. Therefore, integrating these technologies into marketing campaigns can contribute to the creation of sustainable and effective marketing strategies.

Incorporating these advanced technologies in marketing campaigns can lead to more sustainable and effective marketing strategies, contributing to the growth of businesses and industries while protecting the privacy of individuals.

6. ACKNOWLEDGEMENTS

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SINTEZA 2023

APPLIED INFORMATION TECHNOLOGY SESSION

WEB APPLICATION FOR DISPLAYING RESULTS OF AIR QUALITY MEASUREMENT USING VIEW PLUS RADON DETECTOR

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Abstract:

View Plus Radon Detector made by Airthings is a device that allows measuring a number of parameters related to indoor air quality. The device has the ability to connect wirelessly to the Internet, where it is possible to monitor the measurement results later on a purpose-built online platform - Airthings Dashboard. The Airthings Consumer API enables downloading of measured values outside the Airthings Platform as well. This paper presents a web application that allows downloading data from the Airthings Consumer API and displaying them in a graphical environment. This web application was created using React.js, JavaScript, CSS and HTML.

The solution presented in this paper is comparable to other studies results that offer similar functionalities. Similar solutions offer the possibility to monitor air quality parameters as well as our solution, taking into account the fact that hardware and software technologies are versatile and we have not found an identical combination of our hardware and software in other solutions. The display of results on the web offered by our solution is an approach that also exists in some other solutions. Mitigation and prediction are components that exist in some of the other solutions, and our goal is to enable our solutions with a support for these components.

Keywords:

Web Application, React.js, JavaScript, CSS, HTML.

INTRODUCTION

This report presents a web application created using React.js, which is a JavaScript framework and an open source library. The styling and display are done using HTML and CSS, while some functions are made using pure JavaScript. Downloading the data that the detector measures is done using the features offered by the Airthings Consumer API. An illustration of the operation of this web application is also shown. The report also describes some of the previous researches in this area, as well as the values (air quality parameters) that are measured using a detector and displayed in our web application. The chapter on detectors describes the possibilities offered by the View Plus Radon Detector, which measurement results are used by the web application. The API is the next chapter, which briefly describes the possibilities that the API offers for our web application. The web application chapter provides a description and presentation of the operation of our web application.

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2. PREVIOUS RESEARCH

There are studies in the area of measuring radon levels and implementing some methods of radon elimination in case of increased concentrations using the Internet of Things (IoT). Some of them are presented below.

One extensive dissertation [1] presents a system based on the potential of IoT that allows the radon level to be reduced on average by 93% compared to the initial level. "The main objective of this thesis was to develop a solution with IoT technologies, to detect, mitigate and predict radon gas in a home." [1]. Components of this system are a sensor, arduino boards and web services, and a fan was used to reduce the radon level. The data is recorded in the database data, and these data can be viewed in the web application in the form of graphs.

The popularity of low-cost IoT solutions can be seen in [2]. "This work presents a fully automated, low-cost indoor air quality control system that can monitor temperature, pressure, humidity, total volatile organic compounds (TVOC), and radon concentration. Using the radon concentration as an air quality measurement, we created a prediction algorithm. The system uses those predictions to control the ventilation system automatically." [2]. Web the frontend enables the visualization of the condition of the system . The prediction algorithm has the ability to send commands to the control devices that affect the ventilation system. The system is implemented with low-cost and well-known hardware components.

The researches mentioned above are not the only ones from this field. In paper [3], monitoring of radon levels in public buildings is enabled and population notification as well, but mitigation and prediction options are not supported. Greater possibilities are offered by [4], where option mitigate is also supported, but the focus is only on public buildings and option predict is not supported. The work described in [5] is much more suitable for commercial use because it is robust and scalable, but similar to the previous solution, predict option is not supported.

The approach we propose should fulfill the objectives in accordance with the objectives of the above mentioned papers. Developing our own system that we propose is a long-term process, but it allows full control of each of the suggested goals.

3. AIR QUALITY PARAMETERS

View Plus Radon Detector offers the possibility to measure seven parameters of air quality (concentration radon, PM1, PM2.5, VOC, temperature, humidity and pressure). By looking at the values of these parameters, we can get to know of the quality of the air we breathe in a closed space and, if necessary, we can take actions to improve the air quality using different methods and devices.

Radon is a noble, invisible, odorless and tasteless gas that enters the air we breathe in. It is formed by the decay of uranium, and then it can reach the atmosphere from the earth. It has a disastrous effect on human health. Radon particles can cause damage to lung cells to such an extent that lung cancer can occur. Radon concentrations are relatively low outdoors. In a closed space (radon can escape from the ground into the air from building material, water and natural gas) the accumulation of higher concentrations of radon can occur. That is why it is desirable to monitor the level of radon in closed spaces, in order to implement elimination measures in case of concentrations that are higher than allowed ones.

Fine particles of air pollution (mixture of solid particles and liquid droplets) are marked with PM (particulate matter). It is a mixture of smoke, dust, dirt and liquid. The healthier the air is, there are less of these often invisible polluting particles. PM_1 are very small particles with a diameter of 1 micron or less (for example bacteria or corona virus), while $PM_{2.5}$ is made of fine particles with a diameter of 2.5 microns or smaller (e.g. finer dust particles). $PM_{2.5}$ particles which reduce visibility are the greatest danger to human health and can negatively affect the lungs and heart. In Serbia, due to combustion, industry, power plants and automobile exhaust gases, the level of these particles is quite high outdoors in winter when there is no wind and air movement.

Volatile Organic Compounds (VOCs) can cause short-term irritation of the nose, eyes or throat, headaches, but it has also more serious consequences on the liver or kidneys if there is a long-term exposure to higher concentrations to it. This combination of various odors and gases emitted by toxins and chemicals can be found in various items we use in everyday life and it gets into the air we breathe in a closed space. VOCs typically come from paints and varnishes, new furniture, mattresses, carpets, toys, plastics or from cleaning products, cosmetics, and even from cooking and the air we exhale or the smoke of candles and fire. It is often the case that these gases accumulate in higher concentrations indoors and pollute the fresh air.

186

If the detected pollution level is higher than the permitted level, the source of it must be detected in order to remove it.

Carbon Dioxide (CO_2) is a gas known as the cause of the greenhouse effect. Indoors, it comes predominantly from the air which we exhale and from the external CO_2 . If the ventilation is not adequate in a closed space, there is an increase in concentration of this gas, which can become harmful (for example, it can cause reduced concentration and drowsiness, headache, sweating, increased blood pressure).

4. DETECTORS

The detector used for the analysis in this report is the View Plus Radon Detector [6] by Airthings. It is displayed on Figure 1. It is an active type of radon detector based on alpha spectrometry. It also has sensors that measure other air quality parameters. It has the ability to connect wirelessly to the Internet, which allows the results of the measurements to be stored in the Cloud. Those results are later available for viewing or downloading via Airithings online platform (Dashboard) [7]. There is also the possibility to access data through mobile applications created for these purposes. There is another important possibility to use the Airthings Consumer API. The API allows the developer to download the measured data in his own application and still freely work with it according to his needs outside the Airthings Platform. One example of this use can be seen in the presented report. The detector used in this report was received as a donation, and measurements have already been made with it in the frame of the "Radon level measurements" project realized at the Technical College of Applied Studies in Zrenjanin (TCAS) during 2022. The project is financed by the Provincial Secretariat for Higher Education and Scientific Research, and the results of these radon measurements are presented in works [8], [9], [10], [11].

5. API

One of the significant features of using the View Plus Radon Detector is that the measured data can be downloaded and then used further in different applications. This possibility is achieved by using Application Program Interfaces, which abbreviation is API. "An API is a standardized way of interacting with a software application. APIs allow different software applications to interact with each other without having to understand the inner workings of the underlying functions." [12]. Since the user of the API is not familiar with the inner operation of the underlying functions, the API is provided with appropriate documentation. As our subscription level is Consumer, the API documentation we used was Getting Started with the Airthings Consumer API [7]. Consumer customers have limited access version of the API intended for a personal use.



Figure 1 - View Plus Radon Detector [6].

At the "Rate Limits on the Airthings Consumer API" page the limits that exist in our version are given: "A consumer can create 1 Airthings API-client, with Client Credentials Grant authorization. The client can use it to obtain air quality data uploaded by the customer's own device. The API is limited to 120 requests per hour." [7]. The use of the mentioned API requires Authorizing use of the Airthings Consumer API, which is described on the page "Authorizing use of the Airthings Consumer API" of documentation website [7]. The required data are client id and client secret and they are obtained from Dashboard, and based on them, you can request a token from the accounts-api. A token is received as a response. On the page "Authorizing use of the Airthings Consumer API" the next is stated: "The token from the response can be used to access the endpoints in the API until it expires" [7]. For generating tokens in our project we used API platform for building and using APIs named Postman.

6. WEB APPLICATION

The development of the web application was carried out in accordance with the instructions on web page "Node.js Setup Guide" [7] and was adapted to our needs. The basis of the program code is the example recommended in the documentation [13], while free ones were used for the purposes of the GUI icons with [14]. Given the limitations set by our Consumer subscription level, we decided to show the last measured values for the following parameters:

- 1. Date and time of measurement;
- 2. Radon concentration (Bq/m³);
- PM₁ (µg/m²) Particulate matter, fine particles with a diameter of less than 1 microns;
- PM_{2.5} (μg/m²) Particulate matter, fine particles with a diameter of less than 2.5 microns;
- 5. VOCs (ppb) Volatile Organic Compounds;
- 6. CO₂ (ppm) Carbon Dioxide;
- 7. Humidity (%);
- 8. Pressure (hPa);
- 9. Relay Device Type the type of device that performs the measurement; and
- 10. Battery (%) battery charge level.

The web application is publicly available at https:// node-monitoring-air-quality.onrender.com/.

When the user comes to this location, he needs to enter a PIN code. The correct code for the PIN is 0023, and after entering it, the Login button appears. Then you need to click on the Login button. After a successful login, only two buttons appear on the screen: sync (which allows sending requests for getting data) and a button to log out and return to the previous screen.



Figure 2 - Web application after synchronization.

After clicking on sync, you get a screen after synchronization with data. An illustration of the displayed data after pressing the sync button is given in Figure 2.

Time and date of the measurement is shown in the picture. The values of the measured parameters can also be read. Each of parameters has a corresponding icon, name and text value with a unit of measure. The design of the displayed data is adapted primarily to the screen width of smartphones, since these devices represent the most numerous type of device for loading this data today. At the same time, the current display is also kept on classic monitors, so that the design is adapted to all the most commonly used display devices today.

Text related to the parameter can be displayed in three different colors with the following meaning, in accordance with the recommended thresholds on page "View: understanding the sensor threshold" [7]:

- Green good levels;
- Orange average levels; and
- Red poor levels.

The source code of the web application is available at [15].

7. CONCLUSION

This report presents a web application that is used to display the results of air quality measurements based on the data it receives from the View plus radon detector. The values that are measured are briefly described, an overview of the detector is given, the API is described that enables downloading the values measured by the detector, and the characteristics and the operation of the web application. The typically appearing screens during the operation of the web application were also shown. Some other previous researches done in this area were also presented. Taking into account that monitoring both the radon level and the level of other air quality parameters has become an objective, this work represents the first step in that direction.

The approach we propose should fit in with the goals of similar works in this field. Developing our own system using our own strengths is a long-term process, however it allows full control of every step. We believe that such an investment is justified because we already have or can provide all the hardware, software and human resources we need to develop such a system. Furthermore, it is planned to implement a system for alerting about high levels of radon concentration and other air quality parameters, as well as creating a system that would carry out activities to reduce the increased concentration level of radon, VOC and CO_2 with ventilation, as well as optional activation of an air purifier in case of elevated values of other air quality parameters, and all that using IoT potentials. The challenge that follows is the development of a prediction algorithm.

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SINTEZA 2023

THE ROLE OF SOCIAL NETWORKS IN THE COMMUNICATION OF MEDICAL DOCTORS DURING COVID-19 PANDEMIC

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Abstract:

Social media have changed the way people communicate, exchange information, interact, and collaborate. The present research examines the factors influencing the use of social networks by doctors during the COVID-19 pandemic, using the Technology Acceptance Model (TAM). A random sample of 336 doctors working in public hospitals in Greece was used to shed some light on doctors' preferences regarding the use of social networks such as Facebook and Twitter. Doctors reported that they used social networks during the COVID-19 pandemic to read research outputs uploaded by other medical staff and researchers. For both Facebook and Twitter, a positive strong correlation was found between Perceived Usefulness (PU) and Perceived Ease of Use (PEoU). Moreover, Behavioural Intention (BI) was positively related to PEoU and PEoU was positively related to Actual Use (AU). A strong positive correlation was found between BI and AU for Facebook. Finally, BI was positively related to PU, and PU was positively related to AU for Twitter.

Keywords:

Public hospitals, social networks, Technology Acceptance Model, Covid-19.

INTRODUCTION

The development of the internet has led to the emergence of social networks, greatly facilitating the communication of individuals, businesses, and organizations as well as the dissemination of information and knowledge. Social media encompasses online applications and programs that allow users to share varied content and thus network over assorted topics. The expansion of the use of this media form has revolutionized how people share their knowledge and communicate and collaborate while engaging in timely conversations in the workplace [1]. Social media is deemed among the most powerful communication tools of the 21st century [2]. The ascending societal use of social media has encouraged health professionals to use social media in their professional activities [3]. Chan and Leung [4] reported that social networks ameliorated communication and information sharing as well as professional collaboration among healthcare professionals [4]. Hazzam and Lahreck [5] in their research found that 53.6% of doctors used social media platforms for the exchange of peer medical information, and 53.2% used social media several times during the day to improve their interpersonal communication with colleagues [5].

The COVID-19 pandemic had a great effect on the way that people communicated worldwide. Due to social distancing and lockdowns, the use of social networks increased during the pandemic by 27% [6]. Despite the reliability issues, it is worth noting that social networks were used by several professional groups, such as medical doctors, to access information and share research outcomes. For instance, Murri et al. [7], found in their research that 70% of the respondents reported that they used social media to seek medical information during the COVID-19 pandemic.

The primary objective of this research is to examine the factors that influence doctors' intentions to use two popular social networks, namely, Facebook and Twitter, during the COVID-19 pandemic to gain access to recent medical information. To achieve these objectives, the TAM was applied using data obtained from a random sample of 336 doctors in Greece from January 18, 2021, to June 21, 2021. The TAM predicts BI and has been used widely in research to assess technology acceptance.

2. TECHNOLOGY ACCEPTANCE MODEL (TAM)

The TAM was introduced by Davis et al. [8] and involves four constructs: PEoU, PU, attitude towards use (ATT), and AU. Many modified versions of TAM have been studied such as TAM 2, TAM 3, UTAUT [9], [10]. The model depicted in Figure 1 represents a modification of the original TAM and incorporates five constructs [9].

PU denotes the perception of the worthiness of a specific system or application when used in conjunction with the daily tasks of a medical doctor. PEoU denotes the perception of ease while using the system or application. ATT denotes the individual's perception regarding the system or application, for example, "Do I prefer using a specific application or system over an available alternative?".

BI denotes the likelihood of using a certain system or application. AU denotes actual use, which is usually measured by the time or frequency of use of a particular application.

Although AU represents the dependent variable (Figure 1), the dependencies between the constructs can be significant and therefore subject to further investigation. For example, as depicted in Figure 1, PEoU can be considered to influence ATT and PU, PU can be considered to influence ATT and BI, ATT influences BI, and AU can be influenced by BI.

3. RESEARCH METHOD

3.1. SAMPLING METHOD AND PARTICIPANTS

In this research, Facebook, and Twitter, were selected due to their popularity [11], [12]. A measurement tool based on the McGowan et al. [13] instrument was used to evaluate TAM variables. Out of 350 doctors, 336 answered the questionnaire during the third wave of the COVID-19 pandemic in Greece. The sample consisted of 55.7% men and 44.3% women. Additionally, 55.5% of the respondents were under 39 years of age, whereas 44.5% were over 40. Furthermore, 41.4% of doctors held a medical diploma or postgraduate degree (MS or PhD). Doctors' specialties were divided into three main categories: pathology, surgery, and clinical laboratory and laboratory medicine. Of the sample, 40.3% of doctors reported being slightly active each day on social networks, 47.4% were reading research outputs uploaded by researchers and medical doctors, and 38.3% were exchanging messages.

3.2. INSTRUMENT TRANSLATION

To avoid any language issues, the questionnaire and scales were first translated from English to Greek by two translators, and the two translations were compared. The most appropriate translation was chosen in each case until all differences in terms of rendering disappeared completely.



This was then translated back from Greek to English by a third bilingual native English translator by following recommended procedures [14]. The minimal differences found between the original English version and the translation from Greek to English were used to conduct the final adjustments of the Greek translation, for which the translators collaborated directly. To adapt the questionnaire to the data from the public hospitals in Greece, it was modified after the researchers communicated with five doctors from these hospitals. The questionnaire consists of two sections: The first section involves demographic data such as gender, age, educational level, doctors' specialty, frequency of use, and purpose of use (Table 1). The second section involves the TAM variables (Table 2).

		Frequency	Percentage
Corr	Male	195	55.7%
Sex	Female	155	44.3%
	< 30	53	15.1%
4 70	30–39	141	40.4%
Age	40-49	68	19.4%
	> 49	88	25.1%
Education Medical diploma		205	58.6%
Education	Medical diploma and postgraduate degree (MS or PhD)	145	41,4%
	Pathology	194	55.5%
Branches of medicine	Surgery	105	29.9%
	Clinical laboratory and laboratory medicine	51	14.6%
	Facebook (n = 130) or Twitter (n = 8)	138	39.4%
Social networks	Facebook and Twitter	198	56.6%
	None	14	4.0%
	Very active	35	10.0%
Frequency of Use	A little bit every day	141	40.3%
	A few days per week	58	16.6%
	Seldom	102	29.1%
	I do not participate	14	4.0%
	Only views what others are posting	166	47.4%
Designed	Comment on posts related to Covid-19	0	0%
Furpose of Use	You are very active and post frequently articles/surveys almost daily	0	0%
	For exchanging messages	134	38.3%
	All the above	22	6.3%

Tabla	1	Summarizon	domographic	data	atatistica
Table	1 -	Summarizes	demographic	uala	statistics

3.3. RESEARCH HYPOTHESES

The research hypotheses are as follows [5], [10].

- H1: PU while a doctor uses social networks is positively influenced by their PEoU in specific social networks.
- H2: ATT while a doctor uses social networks is positively influenced by their PEoU of the specific social networks.
- H3: ATT while a doctor uses social networks is positively influenced by their PU of the specific social networks.
- H4: BI of social networks to a doctor is positively influenced by their PU regarding the specific social networks.
- H5: BI of social networks by a doctor is positively influenced by their ATT related to specific social networks.
- H6: AU of social networks by a doctor is positively influenced by the BI of the specific social networks.

3.4. FACE VALIDITY AND MEASURES

Out of 50 items originally used, a total of 36 items remained after a face validity procedure (the deleted questions are marked with bold letters in Table 2). In one of the items (PEoU) the reverse wording method was applied to ensure that someone would not mechanically fill in the questionnaire. To evaluate the responses, a five-degree licker scale was used in which 5 represents the most positive value and 1 is the most negative value.

3.5. CONTENT RELIABILITY AND VALIDITY

We used Exploratory Factor Analysis and varimax rotation to check the underlying dimensions of the scale. The internal reliability was checked using Cronbach's Alpha coefficient [15]. All Cronbach's alpha values were found above 0.70, i.e., 0.76–0.98, which indicates good reliability [16], [17], [18]. The Kolmogorov-Smirnov test was used to analyze the suitability of the data for parametric tests. Correlations indicate the degree of influence of one variable on another. A negative correlation means that when one variable increases, the other variable decreases. The Kruskal-Wallis test by ranks, is a non-parametric method for testing whether samples originate from the same distribution [19]. Statistical analysis was conducted using the open-source software Statistical Processing PSPP v.1.4.1. [20].

4. RESULTS

4.1. EXPLORATORY FACTOR ANALYSIS

The first criterion applied was the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy to examine the degree of homogeneity of the variables (0 to 1 scale) [21]. For all the factors with KMO>0.60, the sample appeared to be adequate. The second criterion applied was Bartlett's sample test of sphericity, which examines whether a relationship exists between the variables [22]. For all factors, p=0.000; therefore, the null hypothesis p<0.05) was rejected (Table 3). All initial exports were >0.50, which indicated a good contribution by each sentence to the final model [23]. All questionnaires were found to be valid except for Facebook ATT, which had low validity (52.3% < 65%). In particular, the factor analysis performed on all factors showed a total explanation of over 65%; therefore, the questionnaire was considered valid for Facebook and Twitter, except for the ATT factor, which showed a total explanation of 52.3% (<65%) concerning Facebook. This indicated that the data can be successfully explained using the factor model by limiting individual and random differences in the sample. The model produced one and two factors; however, a single factor was used for the analysis. The analysis of all the factors is presented in detail in Table 2.

4.2. NORMALITY TESTS

The Kolmogorov-Smirnov test did not support the existence of a normal distribution of the data, thus non-parametric tests were used.

Items in the questionnaire	Facebook		Twitter	
PEoU	Fact 1	Fact 2	Fact 1	Fact 2
Using social networks has made or is making my patient care more effective				
I promote healthy behaviors and healthcare outcomes		.72		.85
I am in direct contact with my colleagues	.80		.88	
I discuss current scientific topics in groups	.78		.74	
I communicate with hospital management easily and quickly		.91		.86
It is easy to discuss healthcare and related policy isues	.59	.48		.86
I engage in education and interaction with colleagues or patients	.89		.89	
I engage in interaction with the general public	.83		.77	
I publish the latest valid surveys	.79		.83	
I am informed about the social dimensions of the issue such that patient treatment can be decided	.77		.68	.65
Social media helps facilitate my work		.81		.89
I avoid fake news		.82		.87

Table 2 - Factor analysis with the principal components in a correlation matrix with varimax rotation.

Social network use negatively impacts my working time, Social media helps me quickly share business ideas and information, Social media has lots of false information that prevents people from finding valid information

PU	Fact 1	Fact 2	Fact 1
Social networks allow me to solve health problems fast		.91	.89
Social network improves my performance in critical health matters		.91	.80
Social networks increase my productivity in dealing with health-related issues		.84	.93
Social networks increase my effectiveness in dealing with health-related issues		.87	.94
Social networks help me work better, e.g., by improving communication	.85		.89
Social networks are effective in handling the health issues that I manage	.77		.92
Working without social networks would be difficult	.61		.83
I should spend more time on issues that are currently being resolved immediately	.51	.61	.80
Social networks improve the quality of my work (e.g., via the exchange of views)	.90		.86
Social networks help me focus on important issues	.82		.93
Overall, I find social networks useful for solving health problems	.72		.93

Social networks facilitate the resolution of patients' health problems, Social networks are important to use for my work, Social networks help me manage multiple situations/issues quickly, I use social media too much during working hours

ATT	Fact 1	Fact 1
Social media makes decision-making difficult	.64	.83
The quality of shared information is low in relation to the quantity	.78	.54
Social media use presents a possibility of conflict (conflict of interest) in topics of discussion	.78	.94
Social media has a nontransparent method for peer review and comments	.76	.88
I am anxious while using social networks	.65	.90

I feel that there is insufficient security of private data/discussions on important topics, Social networks help improve the quality of care for my patients, Social media facilitates direct communication, Social media use presents a risk of leaking professional information, Social media increases personal awareness by discovering medical news, Social media helps me relax while working

BI	Fact 1	Fact 1
I prefer to use social networks every day during my work	.97	.95
I plan to use social networks every day at my work	.98	.99
I would use social networks every day at my work	.99	.98
AU	Fact 1	Fact 1
I have the skills to use social networks every day during my work	.84	.78
I have the skills to use social networks effectively for my work	.89	.94
I have knowledge of using social networks for my work	.88	.87
If I need help or face an issue, I know where to go to use social networks properly	.80	.75
I have used social networks effectively in the past many times for my work	.83	.73

4.3. CORRELATIONS BETWEEN TAM FACTORS AND DEMOGRAPHIC

According to our findings (Table 3), a negative correlation was found between PEoU and Frequency of Use (r=-0.56). This finding indicates that the easier doctors think social networks are, the less they tend to use them. Similarly, a negative correlation was found between PU and Frequency of Use, specifically (r= -0.43) for Facebook and (r= -0.52) for Twitter. Furthermore, a negative correlation was found between BI and Frequency of Use (r=-0.67) for Facebook, and (r=-0.50) for Twitter. Finally, a positive correlation was found between PU and Purpose of Use (r= 0.49) for Facebook and (r=0.66) for Twitter.

4.5. CORRELATIONS AMONG TAM FACTORS.

In Table 4, the correlations found between the factors are presented. For Facebook, a positive correlation was found between PU and PEoU (0.83). A strong positive correlation was also found between BI and PEoU (0.68), AU and PEoU (0.66), and AU and BI (0.64). For Twitter, a strong positive correlation was found between PU and PEoU (0.84), as well as between BI and PEoU (0.7), BI and PU (0.69), AU and PEoU (0.7), and AU and PU (0.77). Finally, ATT (Facebook and Twitter) had negative correlations with PEoU, PU and BI.

4.6. DIFFERENCES IN DOCTORS' SPECIALTIES

Differences between doctors' specialties (Pathology, Surgery, Clinical laboratory, or laboratory medicine) were found using the Kruskal–Wallis test (**p<.05). Surgical doctors had lower average use, PEoU, ATT, PU, BI, and AU in all correlations (except Facebook, ATT, and BI) than other specialties. A possible explanation could be that surgeons can't use social networks during their work.

Table 3 - TAM factors - demographic statistically significant correlations $**p < .05$, $*p < .10$.	
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	Sex	Age	Education	Social Networks	Frequency of Use	Purpose of Use
FB PEoU	10*			.14**	56**	.44**
TWT PEoU	29**	31**	13*		56**	.44**
FB ATT	18**	.14**	.23**	49**	.09*	21**
TWT ATT		.13*	.22**	.38**	.14**	48**
FB PU		09*			43**	.49**
TWT PU	23**	28**	20**		52**	.66**
FB BI		19**		.34**	67**	.14**
TWT BI		26**			50**	.40**
FB AU			.09*	.25**	26**	.16**
TWT AU		28**	17**	12*	12*	.62**

Fable 4 - TAM factors statistically significant correlations: *	**p	<.05,	*p<.10)
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	FB PEoU	TWT PEoU	FB ATT	TWT ATT	FB PU	TWT PU	FB BI	TWT BI
FB PEoU								
TWT PEoU	.61**							
FB ATT	15**	20**						
TWT ATT	31**	54**	.69**					
FB PU	.83**	.63**	28**	60**				
TWT PU	.60**	.84**	47**	66**	.75**			
FB BI	.68**	.32**			.51**	.16**		
TWT BI	.52**	.70**	36**	48**	.53**	.69**	.54**	
FB AU	.66**	.15**		.20**	.57**		.64**	
TWT AU	.35**	.70**	41**	64**	.45**	.77**	12*	.46**

5. DISCUSSION

In the present study, half of the doctors participating in the research reported being slightly active each day on social networks and used social networks during the COVID-19 pandemic to read research outputs uploaded by other researchers and medical doctors (Table 1). Hazzam et al. [5] in their research found that doctors used social media several times during the day and used social platforms for the exchange of peer medical information. We found that younger doctors use Twitter more whilst Zerreck et al. [24] in their study found that younger doctors use Facebook more than other social networks. We found a strong positive correlation between PU and PEoU of Facebook and Twitter which is in line with the findings of Pare et al. [25] who found a strong positive correlation between PU and PEoU (Hypothesis H1). In addition, we found a strong positive correlation between BI and PU of Twitter (Hypothesis H4) which is in line with the findings of Melas et al. [10]. Furthermore, we found a strong positive correlation between AU and BI of Facebook which is in line with the findings of Kissi et al. [26] research. We also found a strong positive correlation between AU and PU for Twitter which is in line with the research of Kissi et al. [26]. Furthermore, we found a strong positive correlation between the BI and PEoU of Facebook and Twitter which is confirmed by Orruno et al. [27] in their research. We found a strong positive correlation between AU and PEoU of Facebook and Twitter which is confirmed by Liang et al. [28] in their research Finally, in our sample, ATT had a negative correlation with the rest of the factors of TAM (Table 4) although S. Abdool et. al. [29] in their research found positive correlations between ATT and the rest of the factors. Hypotheses H2, H3, H4 (Facebook), H5, and H6 (Twitter) were not confirmed. The classification of correlations was annotated according to [30].

6. CONCLUSIONS

The COVID-19 pandemic has affected the lives of people in every country on Earth. The general tendency that people have had to look for ways to communicate is also verified in the medical community. The research showed that doctors used social networks during the COVID-19 pandemic as a communication tool for their work. Despite the reliability issues, social networks can contribute to such high requirements for medicine.

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APPLIED INFORMATION TECHNOLOGY SESSION

CREATING AN EDUCATIONAL FRAMEWORK FOR PROJECT MANAGERS AT A SOFTWARE COMPANY: A SAMPLE APPROACH

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Abstract:

Digital innovations and new technologies are transforming our lives, forcing all organisations, especially software engineering companies, to change their business processes. This rapid innovation and technology advancement positively affects project managers' and software engineers' learning and development, encouraging a new corporate, educational approach. In this study, the authors recognised how to keep up with this challenge and ensure the continuous improvement of employees' competencies, giving the company incredible opportunities to increase its performance and efficiency.

The authors of this paper follow the research questions of improving project management education and developing digital skills needed for a sustainable and competitive business environment using e-learning platforms and digital communication channels. This paper presents an approach for designing and implementing a corporate, educational system that trains project managers and software engineers to collect and share acquired knowledge on client projects. Also, this system should reduce the onboarding of newly employed engineers to the company and project managers to new positions.

Keywords:

Software Engineering, Project Management Education, Knowledge competencies, e-Learning Project Management.

INTRODUCTION

Companies that are unready or unwilling to become learning organisations will not survive in the digital transformation era, which is explicitly challenging for software companies [1].

Facilitating knowledge expansion was an essential requirement for Comtrade Project Management Organization (PMO). This extensive software engineering organisation employs over 150 project management professionals across 10 locations, working on over 400 active projects in various project management capacities such as Project Managers, Scrum Masters, Program Managers, and Engagement Managers.

To master and understand the change, our people and organisation had to consider learning and development a never-ending cycle of continuous improvement. A college degree is no longer sufficient to develop the skills needed to respond to rapidly changing business processes and technologies that change multiple times a year. In designing an educational framework for project management education in a software company, it is essential to approach the process with careful consideration and attention to detail. The goal is to create a comprehensive and effective training program that equips employees with the skills and knowledge necessary to manage projects from start to finish successfully. The first step is to thoroughly analyse the company's current project management practices and identify improvement areas. This can be done through surveys, interviews, and observation of recent projects. Once these areas have been identified, developing a curriculum that addresses these needs is next.

The curriculum should cover all aspects of project management, including planning, scheduling, budgeting, risk management, and communication. It should be engaging and interactive, with lectures, case studies, and hands-on exercises. Evaluating the program regularly and adjusting as needed is essential to ensure the training is practical. This can be done through feedback from participants, analysis of project outcomes, and assessments of employee performance.

Designing an educational framework for project management education in a software company requires a strategic and collaborative approach. By working closely with stakeholders, identifying areas for improvement, and developing a comprehensive curriculum, companies can ensure that their employees have the skills and knowledge necessary to manage projects.

2. BACKGROUND AND RELATED WORK

Project Management favourably impacts the software engineering business outcomes. It is defined [2] as "applying knowledge, skills, tools, and techniques to project activities to meet the project requirements. Project management enables organisations to execute projects effectively and efficiently." In the age of globalisation, software engineering companies must define the range of skills and knowledge needed for successful project management to remain competitive.

By studying scientific literature, it was discovered that a vast amount of literature explores the education topic for PM. However, *only a few articles focus on the learning design framework and the conceptual model for development*, especially project management education monitoring. This paper aims to contribute to this study and emphasise the importance of project management education in large software engineering companies, presenting a framework for its custom development and measurement.

Many studies prove that project management's relevant technical and soft skills are not appropriately taught in undergraduate and master's degree programs. Research [3] investigates how project management education is taught in undergraduate degree programs of higher education in computing and its disassociation between theory and practice. A survey that is conducted with software PM educators indicates that there is a particular gap between academic and software industry expectations. As a result, there is a need to improve the project management curriculum, courses, and even student evaluation. However, the challenge of keeping pace with a rapidly changing business environment and technological advances remains since it requires constant adjustment of academic PM education with software industry trends.

Existing research in project management explores how digital innovation changes project management professional development. In [4], the authors present how digital transformation impacts project management performance and whether the current PM curricula match the market's needs. This research explores how PM professional bodies such as IPMA and PMI embrace PM competence development and propose several PM education actions as lifelong learning. The authors suggested organising these ongoing PM learnings and adopting them by PM in practice. Paper [5] identified that Project Management is vital in driving and implementing digital transformation, reflecting changes in their career path, qualification, and certification programs. In a paper [6], the authors point out that introducing systematic education is one of the pillars of the organisation's adaptability to market failures. Systematic education and sharing experiences from past projects are imperative for the organisation's success.

In a series of papers, the authors try to answer how effective and efficient digital education channels are through case studies and analysis based on the target group's research. First, the authors investigate the effectiveness of using the eLearning platform to prepare candidates for software engineering companies [7]. After five years of application, they conclude that it has fully justified its place as a tool in harmonising knowledge acquired at universities and the experience needed to work effectively on fundamental problems in modern engineering practice. Then, in [8], the authors describe a complex solution for education and knowledge exchange in a software engineering company. Finally, in the paper [9], the authors conclude that educational training for employee development within an IT company should efficiently increase professional knowledge.

The authors of this paper share their experiences and explain how to leverage that knowledge through projectbased learning, active and collaborative learning, delivered as face-to-face, self-paced learning, and online training courses under the mentorship of experienced business analysts.

3. METHODOLOGY

In this paper, a combination of qualitative and quantitative techniques is utilised to explore the educational process area in a software services organisation. The focus is on conducting a case study without providing conclusive answers to research questions.

To achieve the general goals of the project, the following steps were taken:

- A quantitative research approach was used to gather data on the company's education state. This involved conducting a survey, summarising the results, and drawing inferences from the data. The survey also yielded a list of desired educational content sorted by priority; and
- 2. Qualitative methods were employed to identify the most frequently used communication channels for sharing educational content. The PM community, offers several such channels, including existing company portals, newsletters, Skype, Slack, emails, audio and video conferences, and live meetings. The tracks with the highest utilisation rates were selected to be included in the PMO Education Roadmap.

4. STUDY, RESEARCH, AND FINDINGS

According to research published in this domain, authors affirmed the importance of custom-tailored, lifelong PM education in software engineering companies, which must be aligned with frequent market changes and measured through the metric system's framework on the corporate level.

The general opinion is that in software companies, after academic education, continuing education for the profession is just beginning.

4.1. FINDINGS BASED ON LITERATURE RESEARCH ANALYSIS.

Based on the findings presented in the literature, several unresolved challenges need to be addressed when developing a software company's project management education framework. These challenges include:

- 1. One challenge in designing a learning framework for project management education is lacking technical, scientific articles focused on this topic;
- 2. The issue of onboarding new members into an organisation's project management team is that relevant technical and soft skills are not consistently taught in undergraduate and master's degree programs. Furthermore, project management practices can vary significantly between companies;
- 3. To maintain existing project management knowledge and disseminate company-specific knowhow, systematically educating and sharing experiences from past projects is imperative. However, this presents a challenge for knowledge acquisition and sharing; and
- 4. Choosing the most effective digital channel to distribute learning content to the right people promptly and encourage collaboration poses a challenge in digital education. Therefore, it is essential to consider the efficiency and effectiveness of these channels.

4.2. FINDINGS BASED ON CUSTOM RESEARCH STUDY.

The project management office at Comtrade created a questionnaire and survey to pinpoint pain points in project management, enhance existing practices, and transfer positive experiences to new projects. There are over 400 active projects, with a trend of starting 20 new ones each quarter. *The PM Insights survey* provides study details and can be accessed through the reference link [10].

The main objective of this study was to identify various aspects of project management practices and requirements and examine gaps to prioritise improvements. The project managers' responses provided valuable information that enabled us to determine areas for enhancement. Additionally, their willingness to share important opinions about the project management field and their connection to PM practices at Comtrade allowed us to identify gaps and critical factors that require improvement. Based on this information, we have created a roadmap for implementing concrete action plans. The study involved 121 individuals (more than 80% of all) who hold positions such as project managers, scrum masters, delivery managers, and program managers. These professionals are directly involved in interacting with engineers and clients and are responsible for ensuring the successful execution of projects and contracts.

The radar diagram and the most significant gap analysis are presented in Figure 1. Table 1 shows Survey results across seven primary categories compared to desired values [10]. The most critical gap emerged in the "Education and Knowledge" (certifications, training) category, followed by the "Methodology" (project management methodology, tools and practice) and "Team" (team collaboration and coordination) categories [11].



Figure 1 - PM Insights Survey results - Radar.

Table 1 - PM Insights Survey - The most significant gaps emerged, and improvement plans.

Category: Education and Knowledge				
GAP: -2.25				
Improvements	How			
Focus on highly specialised educational content related to the latest methodologies or technologies. Accelerate PM, BA, SM, and project team readiness for new roles. Reduce time for project onboarding. Improve domain knowledge coverage. Create systematic and consistent learning content for dislocated teams. Reduce the Cost of learning and education. We are fostering continuous learning and professional development. Category: Project Methodology GAP: -1.50 Improvements Standardisation - create a common language to be understood by all. Formal PM processes improvements. Best practice sharing. Agile delivery – Keep pace with technological rapidly changing. Create project resource libraries and repositories.	Develop PMO EDU portal, Improve PM Newsletters, Rethink PM Coffee Breaks Improve existing PM Community Competence Centre, PM Mentorship and Coaching. How Boost Expert group (Delivery and Processes), New PMO EDU portal content, Filesharing through the Seafile repository,			
Category: Teams collaboration				
GAP: -1.50				
Improvements	How			
Improve team collaboration and communication	PMO EDU portal – offline content PM Coffee Breaks – in-person communication			
Foster is sharing knowledge and personal experience				
Transparancy of expertise promotes personal competences	PM Newsletters - periodicals PMO Slack Channel – groupware, live			
ransparency of expertise promotes personal competences				

In data sources [10], the 2016 PM Insights Survey diagnostic showed that the main pain points were in categories: Education & Knowledge, Methodology, and Teams collaboration. Therefore, the organisation needs to establish a few new or improved processes to increase efficiency and effective project execution support effectiveness with an active role in the project environment's success.

4.3. RESULTS

Based on qualitative research of current project management practice, published scientific literature, and conclusions from a custom research study, the previous two paragraphs present definitive findings that clearly define the scope and direction of future work.

The framework aims to promote education, streamline processes, encourage knowledge sharing, and incorporate distinct terminology into everyday project management practices.

After analysing the latest market demands and survey results, we have identified three primary project goals or focus areas with expected outcomes:

Education and Knowledge

- Support creating and tracking education plans;
- Promote internal events;
- Raise awareness of certification; and
- Simplify learning, and bring closer education.

Methodology

- PM Process standardisation, set of appropriate metrics and relevant process KPIs;
- Formal PM processes improvement; and
- Best practice sharing.

Teams

- Business growth (more people in projects);
- Team optimisation for an agile approach; and
- PM (project managers) and TM (team managers) education.

5. DISCUSSION

The organisational focus shifted towards researching and implementing an educational framework that promotes effective knowledge sharing from our ongoing projects, standardisation of methodology in project management processes, and personalised independent learning tailored to the unique needs of everyone.

5.1. OUTCOMES AND BENEFITS

The PMO project team created a comprehensive solution for the organisation that serves as a central hub for all professional development and career-related needs. This one-stop-shop approach includes easy access to information about the company and its operations. Multiple digital communication channels are available through this platform to promote peer-to-peer communication and teamwork. The effectiveness and advantages of using this system for learning and collaboration rely heavily on the active engagement of all stakeholders.

Such an established framework provides a relational database containing data from all stakeholders in the process, all sources, and all channels across all project life cycle phases. Moreover, combining that data provides plenty of metrics and lists of KPIs that unambiguously show whether a process is effective.



Figure 2 - PMO EDU portal Mind map.
The Comtrade PMO EDUCT portal [12] is a landing page, core for corporate knowledge sharing, collaboration, project resource libraries, aggregator of all initiatives, and a portal around which all additional PM Digital communication channels are developed, as shown in Figure 2. Our approach facilitates unlimited reach, is cost-effective, and addresses the needs of varied and globally widespread learners, keeping us on track to achieve business and project goals.

PMO EDU portal is structured in the following way [8]:

- Courses are distinguished on highly specialised training and tutorials for PMs, Scrum Masters, BAs, and project teams, as custom corporate eLearning content. Each activity includes the lesson's part and, in the end, knowledge validation through test exams and certification [13]. Tutorials help learners master a chosen process and tools;
- To ensure effective project onboarding, **Coaching Corners** are for everyone interested in Scrum Master and BA, with mentorship program plans, shared personal experience, solutions for everyday Scrum and BA problems, best practices, and tool recommendations;
- Knowledge database vocabulary short educational content:
 - » WHAT IS: basic concepts of project management terms, tools, or techniques. The specific subject is explained to help PM practitioners easily understand and apply new knowledge;
 - » HOW TO: provides step-by-step information about some specific concept. These materials are tutorials that lead the user through the key features, functions, or steps that progress through a logical sequence to understand all the user's elements;
- Certificates database: Place where our colleagues' certificates are updated continuously and transparent our hall of fame. The base contains Scrum Master, Product Owner, and PMO EDU certificates. We are always up to date with the knowledge and competencies of our employees;
- PM Brochures: Corner, where our project manager generously shares their knowledge and experience with others, is about global PM practices or internal expertise and skills;
- **PMO Forum**: Place for discussion and sharing knowledge peer-to-peer; and

• **Support**: It can be found frequently asked questions, contacts, and call to action to contribute by sharing content and ideas.

Other Multiple PM Digital communication channels available within the framework are:

- To gather community feedback, **Comtrade PM**, **surveys**: Survey questions and results lead us to find out the best improvements for the future, so as the concrete next steps that we can take to be more successful in project management and consequently on the market;
- The PM Knowledge Sharing initiative is being realised through PM Coffee Brakes and BA Coffee Brakes, held monthly as a delight for the whole PM community. Topics from best PM/BA practices and knowledge are discussed and shared within the community. Video and audio recordings from every session are always available here;
- To promote team culture PMO Newsletter: As a part of the monthly updating community with upcoming trends in the industry, news, internal and external events, conferences, training, or achievements in a for-on newsletter is being uploaded into the archive, so none of the information is missed;
- To foster collaboration **PM Slack channel:** Helps PM harmony and teamwork efficiency through messaging and team-oriented channels; and
- To encourage community exchange **Seafile**: PM internal share point for all documents, video sessions, tutorials, and templates.

6. CONCLUSION

This paper contributes to applying such a solution in practice and has an original contribution as an authentic approach. This framework allows us to pivot and adjust the KPIs anytime, respond to business priorities, or adapt to any company's situation.

With the presented approach, the company accomplished digital growth goals in all critical areas of PMO responsibility - standardisation of the process, the unification of project management tools, onboarding new PMs into the project organisation, and training them in specific project practices sharing knowledge and experiences from projects.

- A common language to be understood by all;
- Sharing knowledge and experience;
- Continuous professional development for Project, Program and Engagement Managers, Scrum Masters, and project teams;
- Accelerate professional training while balancing discipline with agility;
- Transparency of expertise, promotion of personal competencies;
- Assessing a PM professional's capability; and
- The following survey and framework assessment will show the directions of further development.

This paper aims to encourage organisations to create their own and adopt a framework exposed to its realistic priorities and needs in SW development that depend on: the dynamics and requirements of their clients, the capabilities and performance of their employees, and government expectations and investments.

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APPLIED INFORMATION TECHNOLOGY SESSION

MODEL FOR PERSONALIZATION OF SALES PROMOTIONS BASED ON BEACON TECHNOLOGY

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Abstract:

Companies are making great efforts to develop personalized offers for customers. However, many customers consider that it is inappropriate to receive offers that they are not interested in, to receive an excessive number of simultaneous sales promotions, or receive them frequently, or even to receive promotions in an untimely manner. Although online shopping is constantly on the rise, when it comes to retail sales, the number of online purchases is still significantly lower compared to the number of in-store purchases. In this paper, we present a model of a smart retail environment that tracks customer activity inside the store and sends them personalized promotions while they are still at the store. The smart environment is based on the use of beacon technology and an appropriate relational database. The main benefits of this approach are increasing the company profits by sending personalized promotions to customers at the right time, increasing customer satisfaction, and collecting data on customer behaviour in the store for future analysis. For the purposes of experimental verification of the model, a test database was created, and the paper shows a number of queries executed in it.

Keywords:

Beacons, Smart Retailing, SQL Database, Personalized Promotions.

INTRODUCTION

The development of IoT (*Internet of Things*) technology, as well as the constant increase in the number of applications that use the information on user's location, lead to the increasing popularity of location-based services. The main employment of location services is the navigation service, and also, the services of monitoring and surveillance, geomarketing and advertising, or mapping. The location services are used in sports, medicine, video games, social networks, business, and commercial applications as well. Combining the information on the location together with other information relevant to the user opens up the possibility for numerous applications of these services. The beacon technology is being increasingly implemented for location, navigation, and tracking services in indoor venues such as museums, theatres, cinemas, airports, shopping malls, stores, etc.

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Although online shopping is constantly on the rise, when it comes to retail sales, the number of online purchases is still significantly lower compared to the number of in-store purchases. According to [1], in 2022, in Great Britain, the percentage of online retail sales accounted for about 27% of total retail sales. For textiles, clothing, and footwear, this percentage is even lower coming in at about 23% for the month of December 2022 [1]. This data points to the need to create a smart in-store environment and personalized promotions for customers that would be presented to them while they are shopping in that particular store. Thanks to a number of benefits, such as high energy efficiency, precise positioning, low cost, and simple implementation, the beacon technology is being increasingly used to create a smart environment in stores. The implementation of location services in the majority of applications used on a daily basis indicates that users agree to disclose information about their location because they benefit from it. Weather apps, social networking apps, apps like Viber and WhatsApp, as well as various delivery and traffic tracking apps, all use location information nowadays. Numerous researches on customer acceptance of beacon technology, and on the influence of this technology on business, have been conducted. Recent studies [2] – [6] show a positive customer response to beacon technology, as well as an increase in customer satisfaction. The research [3] addresses the acceptance of beacon-triggered promotions in smart retail, having examined the markets of Serbia, Croatia, and Bulgaria.

In this paper, we present a model of a smart retail environment that tracks customer activity inside the store and then sends them personalized promotions while they are still in the store location. The smart environment is based on the use of beacon technology and an appropriate relational database.

The main benefits of this approach are an increase in company profits when personalized promotions are sent to customers at the right time, an increase in customer satisfaction, and the collection of data on customer behaviour in the store which can be used to increase business efficiency in the future. The paper is organised as follows. A brief overview of beacon technology is presented in Section 2. In Section 3, the concept of a smart environment and the corresponding SQL database are presented. The process of creating a test SQL database is also described. Subsequently, an overview of the most significant results that indicate the advantages and possibilities of the system described in this paper is presented in Section 4. And ultimately, conclusions and a direction for future studies are provided at the end of the paper.

2. BEACON TECHNOLOGY

Beacon technology was introduced by Apple in 2013. The global beacon market size was USD 1.36 billion in 2018 and is projected to reach USD 31.61 billion by 2026 [7]. Beacon devices are small devices that use battery power and BLE (Bluetooth Low Energy) technology to broadcast radio signals to nearby smart devices that have the proper application installed and Bluetooth enabled. Beacon devices emit a UUID (Universally Unique IDentifier), a major and a minor number that uniquely identify the beacon device [8]. Based on this information and the Received Signal Strength, it is possible to determine the location of a smart device which is then used to initiate the appropriate action, such as sending notifications to the smart device. Figure 1 illustrates the basic operation of beacon technology in smart retail.



Figure 1 - Functional process of beacon technology in smart retail.

The concern of the companies about the number of customers who would have their Bluetooth enabled and store apps installed on their phones is unfounded [4]. Due to the increasing popularity of smartwatches and wireless headphones, most mobile users have Wi-Fi and Bluetooth enabled at all times [4]. When it comes to the store application, there are also alternative solutions, such as using the application of the shopping centre where the store is located. However, companies have not yet understood all of the benefits of introducing beacon technology into retail.

There are numerous scientific research papers that deal with beacon sensor networks for various purposes. In [9] architecture for museums, location-based content delivery using augmented reality and beacons was proposed. A smart airport system based on beacon technology is developed in [10]. Beacon technology was widely used during the pandemic caused by the Covid-19 virus to develop a system for monitoring risky contacts [11].

3. SMART RETAIL MODEL

3.1. BASIC ASSUMPTIONS

The general idea is to deploy enough beacon devices in the retail store so that each article is within range of at least one of them. If the store has a fitting-room, then the beacon devices must be installed in it. Based on the customer's movement around the store, the type of article the customer is interested in can be predicted.

On the other hand, depending on the time spent in various areas of the store, it is possible to anticipate whether or not the customer will make a purchase. The acquired data can be used to determine whether or not to send a promotional message to the customer via the application. If a message about a promotion is to be sent to the customer, it is necessary to determine which promotion should be sent to the customer, i.e., what type of article is the discount granted for.

3.2. DATABASE STRUCTURE

All necessary information for the smart environment is expected to be stored in a relational database. In reality, authorised personnel of companies and stores should enter a number of data points (e.g., data on companies, stores, articles, etc.); the next data set is obtained from the mobile application installed on the customer's phone (customer data); and the third data set is obtained from the beacon device (UUID, major, minor, battery, etc.). The relational database was built with *Microsoft SQL Server. SQL* has been chosen as the industry standard for data in almost all computing applications [12]. The created database consists of 13 tables. Table 1 summarises the properties of each table and the relationships between the tables. In the second column (Table attributes) the primary key of the table is highlighted, while the foreign key is listed in parentheses in the third column, relationships. Companies, stores, beacon devices, customers, articles, transactions, and promotions are the key entities in the database.

3.3. GENERATING A TEST DATABASE

In order to fill in the dataset tables with the data required to evaluate the suggested approach, a random data generator, Excel, and SQL scripts were employed. In the absence of large real-world data sets, this method of filling in the database was required. The test database stores data from 300 beacon devices installed in 30 stores. In addition, data on 1.181 clients and nearly 3.000 articles were captured. There are currently 121 active promotions. The promotion was sent to 682 customers, and the total number of transactions recorded in the system is 684. Initially, the use of a random data generator was intended to fill in all the tables of the test database. It was not possible to use the random data generator for all database tables due to a number of criteria that had to be met to obtain consistent data. The random data generator was used when generating data for the company, store, beacon, customer, people_counter data tables, as well as for a part of the article data table. All the data on the customers, which they made available through the app setting, is placed in the customer table. The people_counter table is designed to obtain information on the number of customers who do not use the system described in this paper. The beacon table's key attributes are the UUID, major, and minor numbers that allow identification of the beacon device. The UUID is used to identify the network to which the beacon belongs, in this case, the company itself. The major number is associated with a smaller set of beacons at a given location, i.e., a specific store. The minor number corresponds to the specific beacon device in the shop, i.e., the articles in the coverage zone of the beacon device. The beacon table also contains other technical data, such as the status of the beacon device and its battery, which are required to keep the system operating.

Relationships
rticle (company_id) promotion (company_id) tore (company_id)
eacon (store_id) eeople_counter (store_id) ompany (company_id)
tore (store_id) eacon_customer (uuid, major, minor) eacon_article (uuid, major, minor)
eacon (uuid, major, minor) ustomer (customer_id)
eacon_customer (customer_id) ransaction (customer_id) ustomer_promotion (customer_id)
ompany (company_id) peacon_article (article_id) ransaction_article (article_id)
rticle (article_id) eacon (uuid, major, minor)
ustomer (customer_id) promotion (promotion_id) ransaction_article (transaction_id)
ransaction (transaction_id) rticle (article_id)
ransaction (promotion_id) ompany (company_id) ustomer_promotion (promotion_id) promotion_criterion (promotion_id)
ustomer (customer_id) promotion (promotion_id)
promotion (promotion_id)
tore (store id)

Table 1 - Database structure overview.

Scripts written in *SQL* were used to generate data for the beacon_customer, beacon_article, customer_ promotion, transaction, and transaction_article tables, as well as for a portion of the articles table. The majority of the tables listed above have a significant number of complex criteria that had to be met, which was not achievable through the generation of random data. The created scripts simulate the movement of the customers around the store, interaction with beacon devices and objects in the store, and the purchasing process. The created scripts allow for different collections of data each time they are performed.

The time of entry and exit of the customer from the beacon device zone is stored in the beacon_customer table for all beacon devices in the system. This information is critical in determining the type of article the consumer is interested in and deciding whether or not to send a promotional message to that customer. For data generation, an *SQL* script using a cursor that simulates the customer's movement around the store and interaction

with beacon devices was written. At a predetermined interval, the script creates a random customer entry and exit time for a specific store. The moment of entering the store corresponds to the in_zone attribute, which is increased by a random time interval, resulting in the value of the out_zone attribute for the observed beacon. The out_zone value of one beacon device represents the value of the in_zone attribute of another randomly selected beacon device. This procedure is repeated until the customer exits the store.

In the article table, name, price, article id, and company were generated using a random data generator. For the class attribute, no random data generator was used. Following that, the article class data is constructed using the *SQL* script in such a way that it can take one of the 19 predefined values: jacket, coat, trench coat, suit jacket, overalls, dress, skirt, shorts, pants, jeans, shirt, t-shirt, sweatshirt, bag, accessories, sneakers, shoes, sandals, boots. Articles from a minimum of one and a maximum of three classes are assigned to beacon devices. After the generation of the beacon_article table, the data on the class of articles is also placed in the article table.

In the customer_promotion database, promotions are assigned exclusively to those customers who meet the criteria for sending the promotion. An SQL script was also created for data generation. The script uses a cursor to determine the total amount of time spent in the store, the amount of time spent in the fitting-room, and the amount of time spent with a specific class of articles for each customer. The customers who meet the criteria given in both the promotion and the promotion_criterion tables are then verified. An SQL script is used to get 30% of randomly selected customers from the customer_promotion table and create a transaction for them, where the purchased article class matches the article class of the sent promotion. It is assumed that some of the customers who received the promotion will not use it for the transaction. The script also randomly selects 10% of customers from the customer_promotion table and creates transactions without promotion for them. In addition, the script generates transactions for unidentified customers, that is, consumers who do not use the technology described in this work, so 60% of total transactions are non-promotional and non-customer id transactions.

The promotion and the promotion_criterion tables were manually created in *Excel* before being imported into *Microsoft SQL Server*. The reason for this is an attempt to meet as many real criteria for different types of articles as possible.

For example, most clothing promotions are based on time spent with the article and time spent in the fittingroom, as it is anticipated that customers would want to try on certain pieces of clothing they are interested in. In the case of footwear, the criteria for sending a promotion are the amount of time spent with the article and the total amount of time spent in the store.

4. RESULTS AND ANALYSIS OF RESULTS

The proposed smart environment, which is based on beacon technology and a relational database, can provide numerous benefits to potential users, primarily companies and stores. After the creation and filling in of the test database, a series of queries were executed, obtaining useful derived information that showed interesting patterns in the data.

The information on unused promotions can be quite valuable to companies. A large percentage of unused promotions for a specific article class may indicate that the criteria used to deliver the promotion should be changed. Figure 2 shows a graphic representation of the total number of unused promotions, sorted by article class. From Figure 2, it can be seen that the largest number of customers, 41, did not use promotions for sneakers, while only 8 customers did not use promotions for accessories.



Figure 2 - Number of unused promotions by article class.

It is necessary to focus on transactions where customers did not use promotions even though they were sent to them. Table 2 shows the purchased article class and the promotional article class for the selected category of transactions. From Table 2 it can be observed that customers to whom a promotion for shorts and sweatshirts was sent often decide to buy an article from another class. Furthermore, as shown in Figure 2, the total number of unused promotions for shorts and sweatshirts is large, indicating the necessity of verifying the criteria for delivering promotions for the stated article classes.

When the customer receives a message with a promotion, it can influence not only the decision whether to make a purchase or not, but also the precise article to purchase. Table 3 provides an overview of the average sum of transactions with promotion, without promotion, as well as the average sum of transactions for customers outside the beacon system. From Table 3, it can be observed that the average number of transactions with promotions is greater than the average number of transactions without promotions for the majority of the dates listed. For example, on 25.12.2022 the price of transactions with promotion was even 59.95% higher than the price of transactions without promotion. According to the inquiry results, customers who use promotions purchase more expensive products. In addition to data on unused promotions and the average price of different types of transactions, tracking the number of customers who do or do not use the beacon system can have an impact on the company's business. It is for this reason that the database contains the people_counter table. The total number of customers, as well as the specific number of customers inside and outside the system, can be easily obtained by query. An increase in the number of customers within the system would mean a positive response to the system by customers, as well as an increase in customer satisfaction and system popularity.

To ensure the smooth operation of a system with a large number of beacon devices, all beacon devices must work properly. If one of the beacon devices used to measure the time spent with a certain class of article, e.g. sneakers, is out of order, customers will not receive a sneaker discount promotion. On the other hand, a poor operation of a beacon device in the fitting-room affects a substantially larger number of promotions, that is, all of the promotions where the time spent in the fittingroom is one of the criteria. One of the disadvantages of the beacon system is its maintenance, as well as company concerns about the battery life of the beacon device [2]. As a result, the status and the battery attributes are presented in the beacon table. In this way, the battery life can be easily monitored, and the staff in charge of system maintenance can respond in a timely manner.

Table 2 - Class of the purchase article and promotion article for transactions with promotion that was sent
but not used at the time of purchase.

Class of the purchased article	Promotion article class	Number of transactions
trench coat	shorts	4
sweatshirt	shorts	4
jeans	shorts	4
coat	sweatshirt	3
trousers	sweatshirt	3
jeans	jumpsuits	2
shirts	sweatshirt	2
trench coat	sweatshirt	2

Table 3 - Average price of different types of transa	actions.
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Type of transaction	21.12.2022	22.12.2022	23.12.2022	24.12.2022	25.12.2022
average purchase price without promotion	20882.11	25357.04	18267.67	32759.64	15624.73
average purchase price with promotion	21646.20	27234.04	25972.03	31485.85	26061.01
average purchase price outside the system	22066.34	21279.49	28544.22	25409.51	27624.62

gender	year of birth	promotion send	completed transaction	used promotion
male	1971	1	1	1
male	2000	1	1	0
female	1988	1	1	1

Table 4 - Part of dataset used to analyse how customer demographics affect the promotion utilisation.

According to [12], analysts spend about 80% of their time preparing data for analysis and developing models with impure data, which is detrimental to the analysis and leads to bad results. An *SQL* gives the user the ability to extract, filter, update, sort, and manipulate data. Furthermore, *SQL* includes a vast number of different aggregate functions that allow detecting interesting patterns in data, in addition to the ordinary arithmetic operations, functions for working with character data and dates, and logical and set operators. A wide range of queries were executed during database testing in order to prepare the data for analysis.

Table 4 displays a portion of the query results used to examine how customer demographics influence promotion utilisation. The information on the gender and date of birth is available for 305 customers, 134 of whom received a promotion, and the dataset containing their records was used for the analysis. The transaction was carried out by 55 customers in the dataset, where a total of 43 promotions were applied. The majority of customers, 92 of them, are men. The birth years of the customers range from 1971 to 2003. For the purpose of the analysis, a decision tree model was created, Figure 3. The model testing took up 30% of the data. The model's accuracy is 75.61% (True Negative 70.73% and True Positive 4.88%). From Figure 3 it can be observed that promotions are most frequently used by customers of both genders born after the year 2000.

At the same time, the gini index for females reached 0, indicating that the node is perfectly homogeneous and there is no impurity or uncertainty in the node classification. On the other hand, the gini index of 0 could indicate overfitting of the model to the training data, so the result is not always desirable.

It is necessary to point out that the analysis of the impact of customer demographic variables on the use of a promotion was conducted on a small dataset with customer data generated completely random. A random data generator was used to create consumer data, and then a simulation of client movement and interaction with beacon devices and objects was performed. The analysis was carried out with the aim of demonstrating to the potential database users how the acquired data, along with machine learning, may be used to precisely identify the criteria for sending personalized promotions. One of the most significant tasks for the proper implementation of the system is determining the criteria on when to send personalized promotions. It is crucial to identify the critical moment when to deliver the promotion to the customer. The sending of the promotion can influence not only whether or not a consumer would buy, but also the specific selection and number of articles they buy. As a result, the company's profit and customer satisfaction can be increased, which is the system's main goal.



Figure 3 - A decision tree model used to evaluate the utilization of promotions based on customer demographics.

212

5. CONCLUSION

Beacon technology and relational databases are excellent solutions for creating a smart retail environment. The main benefits of this solution are: increasing the company's profits by sending personalized promotions to customers at the right time; increasing customer satisfaction; and collecting data on customer in-store behaviour that can be used to increase business efficiency in the future.

Within the system described in this paper, the criteria for sending promotions are determined subjectively due to the lack of real data. In the further course of the research, cooperation with real companies is planned in order to obtain real datasets about customers who visit their stores. The dataset should contain the data on customer retention for individual article classes, total time spent in the store, time spent in the fitting-room, data on customer gender and age, as well as the transaction data, including the information on whether a transaction was made and, if so, on the product class or the article that was purchased. Such a dataset would allow machine learning to be used to identify more precisely the criteria for providing personalized promotions, which would benefit both companies and customers.

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APPLIED INFORMATION TECHNOLOGY SESSION

COMPARATIVE STUDY OF THREE METHODS FOR BRAIN TUMOR DETECTION AND EXTRACTION USING IMAGE SEGMENTATION TECHNIQUES

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Abstract:

Image segmentation is the process of dividing a digital image into image segments so that individual regions of interest can be analyzed and processed instead of the entire image. Image segmentation has a significant role in detecting regions of interest and extracting attributes and regions from those images. In this paper, five original grayscale abnormal MRI brain images have been processed by using image segmentation techniques for detecting and extracting regions of interest, in this case, tumors. This research described three methods of detection and extraction of tumors from abnormal MRI brain images in MATLAB: a method based on combined local threshold segmentation techniques with morphological operations for tumor detection; a method based on region splitting and merging segmentation techniques; and a method based on combined thresholding, Meyer's flooding watershed algorithm, as an image segmentation technique with morphological operations for tumor detection. Abnormal MRI brain images were preprocessed in order to obtain suitable results. Image data used in this research were obtained from Radiopedia, an educational radiology resource. The best method for detecting and extracting tumors has been determined by comparing the results of accuracy, sensitivity, F-measure, precision, MCC, dice, jaccard, and specificity. Based on the results of these measurements, it has been concluded and confirmed that the first and third methods are both equally good for detecting and extracting tumors.

Keywords:

MRI, Image Segmentation, Thresholding, Region Splitting and Merging, Watershed.

INTRODUCTION

In the medical field, magnetic resonance imaging (MRI) as one of the diagnostic methods is very often used to, for example, detect and analyze abnormal changes in brain soft tissue defined as tumors. Image segmentation and detection are very important methods used to distinguish the abnormal from the normal brain tissue and to localize, in this case, the brain tumor. Segmentation algorithms are focused on an area instead of an individual pixel. [1] Segmentation algorithms are based on similarity, which is one of the basic properties of intensity values. [2] This paper gives a comparative study of three proposed methods using image segmentation techniques for the detection and extraction of tumors from abnormal MRI brain images in MATLAB.

Input abnormal original MRI brain images are preprocessed and improved in terms of noise reduction, smoothing, sharpening, and contrast enhancement to get some useful information about the size, shape, and location of abnormal tissue in the brain and to improve the accuracy of applied segmentation techniques. In all three methods, 2-D median filtering is used as an in-built function for reducing noise and smoothing, and local Laplacian filtering is used as an in-built function for image sharpening. The first method is based on combining local threshold segmentation techniques with morphological operations for tumor detection. The second method is based on region splitting and merging segmentation techniques, and the third method is proposed by Rajesh C. Patil and DR. A. S. Bhalchandra, which is based on combined thresholding and Meyer's watershed algorithm as segmentation techniques with morphological operations for tumor detection. [3] Images and data used in this paper were obtained from Radiopaedia, an educational radiology resource.

2. IMAGE PREPROCESSING

In preprocessing, the input MRI images are processed in different ways, such as filtering to remove or reduce noise, image sharpening, and registration to make all images comparable with each other. In this paper, in the methods, we applied image resizing to all five original input MRI images and edited the images in the same manner to obtain more accurate results. Various filters can be used for noise reduction, and in this paper we used the 2-D median filtering in-built function in MATLAB. Generally, the median filter is a non-linear operation that works so that the median filter passes through the image entry by entry and replaces the value of the center pixel with the median of the intensity values in the neighborhood of that pixel. [4] The median filter is effective when it is necessary to simultaneously remove noise and preserve edges. 2-D median filtering performs median filtering of the image in two dimensions. Each output pixel contains the medium-value 3-by-3 neighborhood around the corresponding pixel in the input image. [5] [3] In this paper, we also used an in-built function for fast local Laplacian filtering in order to increase the contrast of an image. In a fast local Laplacian filtering function, the parameter sigma characterizes the amplitude of edges in an image, and the parameter alpha controls the smoothing of details. The sigma and alpha parameters were determined experimentally based on human vision, and they are 0.3 and 0.4, respectively.

3. COMBINED LOCAL THRESHOLDING SEGMENTATION TECHNIQUE WITH MORPHOLOGICAL OPERATIONS

In the local thresholding technique, the threshold value *T* depends on the gray levels of f(x,y) and some local image properties of neighboring pixels. The threshold operation with a locally varying threshold function T(x,y) is given by Equation 1.

$$g(x, y) = \begin{cases} 1 \text{ if } f(x, y) \ge T(x, y) \\ 0 \text{ if } f(x, y) \le T(x, y) \end{cases}$$
(1)

$$T(x, y) = f_0(x, y) + T_0$$
 (2)

Equation 1 - The threshold operation with a locally varying threshold function.

The image is the morphological opening of f, and the constant is the result of the function graythresh applied to. Morphological operations extract image features such as the shape of the region of interest or some other morphological features of an image and basically transform the image. [1] [6] Erosion and dilation are applied in this paper to detect the tumor.

All five original abnormal MRI brain images as input images are preprocessed by applying 2-D median filtering for noise reduction and smoothing and fast local Laplacian filtering for image sharpening. After that, images were resized, and different threshold values of parameters T_0 were applied to different input images in order to get accurate results for the detection of tumors and for converting grayscale images into binary images. For images I_1 , I_3 and I_4 it is applied $T_0=30$, for image I_2 it is applied $T_0=20$ and for image I_5 it is applied $T_0=0.2$. To segment out the tumor location from the image, it is required to create a binary tumor-masked window. By putting a tumor mask on dilated MRI brain images, the final image is obtained with a detected tumor. In the end, accuracy, sensitivity, specificity, the Sorensen-Dice, and the Jaccard metrics are calculated to estimate the success of the segmentation task. Accuracy (%) measures how well a binary segmentation method correctly identifies a condition in Equation 2, where TP, TN, FP, and FN denote true positive, true negative, false positive, and false negative, respectively.

> $accuracy = \frac{TP+TN}{FN+FP+TP+TN}$ Equation 2 - Accuracy (%).

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Sensitivity (%) is evaluated as the proportion of real positives that are correctly identified in Equation 3. Specificity (%) is computed as the proportion of real negatives that are correctly identified in Equation 4.

 $sensitivity = \frac{TP}{TN+FN}$ Equation 3 - Sensitivity (%).

specificity =
$$\frac{TN}{TN+FP}$$

Equation 4 - Specificity (%).

The Sorensen-Dice score is another way to measure segmentation accuracy and is computed as follows in Equation 5 and the Jaccard score has a relation with the Dice similarity as follows in Equation 6.

$$dice = \frac{2TP}{2TP + FP + FN}$$

Equation 5 - The Sorensen-Dice score.

$$jaccard = \frac{dice}{2-dice}$$

Equation 6 - The Jaccard score has a relation with the Dice.

The higher mentioned scores, the better the segmentation results. [7]

4. REGION SPLITTING AND MERGING SEGMENTATION TECHNIQUE

Region splitting and merging are segmentation techniques that are based on finding the regions of interest directly in such a way that region splitting subdivides the whole image as a single region into its subsidiary regions again and again until a condition of homogeneity is satisfied. The region-merging technique works in the opposite way to the region-splitting technique. [5]

All input MRI brain images are preprocessed in the way described in the first proposed method. We were able to segment the region of interest using the following Equation 7.

 $Q = \begin{cases} \text{TRUE if } \sigma > a \text{ AND } 0 < m < b \\ FLASE \text{ otherwise} \end{cases}$

Equation 7 - Segment the region of interest.

Where *m* and σ are the mean and the standard deviation of the pixels in a quad region, and *a* and *b* are constants. [8] In this paper, it is applied that constant a is less than 200 and constant b is greater than 5. The size of the quad regions is different for input MRI images.

The image size I_1 for the quad regions is 16. The image size for the quad regions is 16, and the image size of I_2 and I_5 for the quad regions is 2. The image size of I_3 and I_4 for the quad regions is 4. The result of the split and merge procedure is used as a mask and multiplied with the input image to detect tumors in the input MRI brain image. In the end, accuracy, sensitivity, specificity, the Sorensen-Dice, and the Jaccard metrics are calculated in the same way as they were described in the first proposed method.

5. COMBINED THRESHOLDING AND MEYER'S FLOODING WATERSHED SEGMENTATION TECHNIQUES WITH MORPHOLOGICAL OPERATIONS

According to Rajesh C. Patil and A. S. Bhalchandra, the method based on combining image segmentation techniques such as threshold and Meyer's flooding watershed algorithm with morphological operations for tumor detection is very efficient. The Meyer's flooding watershed algorithm works on a grayscale image. During the successive flooding of the gray value relief, watersheds with adjacent catchment basins are constructed. This flooding process is performed on the gradient image, i.e., the basins should emerge along the edges. This will lead to over-segmentation of the image, so the image must be preprocessed. [3] [9]

All input MRI brain images are preprocessed in the way described in the first proposed method. Threshold segmentation is based on a threshold value to turn a grayscale image into a binary image, and the value that is applied is 0.6. Meyer's flooding watershed algorithm [3] procedure is applied to a thresholded image. Finally, morphological operations are applied for tumor detection. In the end, accuracy, sensitivity, specificity, the Sorensen-Dice, and the Jaccard metrics are calculated in the same way as they were described in the first proposed method.

6. RESULTS AND DISCUSSION

This paper elaborates on different methodologies based on different image segmentation techniques and morphological operations for tumor detection and extraction, providing an insight as to which method should be utilized for a more reliable estimate of the segmentation results of the original image using accuracy, sensitivity, specificity, the Sorensen-Dice, and Jaccard evaluation factors. The abnormal original MRI brain images of 512x512 pixels [10] have been used for tumor detection and extraction by various proposed methods. The first proposed method gives us the visualized results shown in Figure 1. According to human vision, the first proposed method gives a very efficient result. There are 5 MRI brain tumour images over which the algorithm from the first proposed method is applied. The measurements of the abnormal MRI brain greyscale images on which the first proposed method ia applied are described in Table 1. All of the MRI images are processed through the MATLAB code.



Figure 1 - a) Original abnormal MRI image, b) denoised image, c) Laplacian filtered sharpened image, d) segmented tumor, e) eroded image, f) tumor outline, g) detected tumor.

MRI images	Accuracy (%)	Sensitivity (%)	Specificity (%)	The Sorensen-Dice (%)	Jaccard (%)
$I_1[11]$	91,99	74,27	99,97	85,20	74,22
$I_{2}[12]$	94,91	96,99	94,50	86,17	75,70
<i>I</i> ₃ [10]	95,92	93,97	96,82	93,55	87,88
I ₄ [13]	95,29	87,90	99,73	93,38	87,58
$I_{5}[14]$	90,53	69,41	99,86	81,79	69,19

Table 1 - Resulted Accuracy, Sensitivity, Specificity, the Sorensen-Dice and the Jaccard measurements.

The second proposed method gives us the visualized results shown in Figure 2. According to human vision, the second proposed method gives a less efficient result. As a final result, we obtained a segmented tumor, but there is missing information about pixels and parts of regions of normal brain tissue. The measurements of the abnormal MRI brain grayscale images on which the first proposed method was applied are described in Table 2. All of the MRI images are processed through the MAT-LAB code. The third proposed method gives us the visualized results shown in Figure 5. According to human vision, the third proposed method gives a very efficient result. The measurements of the abnormal MRI brain grayscale images on which the third proposed method was applied are described in Table 3. All of the MRI images are processed through the MATLAB code.

Based on Tables 1, 2, and 3, we can conclude that the better results for accuracy, sensitivity, specificity, the Sorensen-Dice, and the Jaccard measurements are obtained by applying algorithms for the first and third proposed methods on abnormal original MRI brain images than by applying algorithms for the second method.



Figure 2 - a) Original abnormal MRI image, b) denoised image, c) Laplacian filtered sharpened image, d) segmented tumor by split and merge procedure, e) segmented tumor used as a mask for detection, f) detected tumor.

Table 2	- Resulted	Accuracy, Sen	sitivity, Spe	ecificity, the	Sorensen-Di	ice and the	Jaccard	measurements.
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MRI images	Accuracy (%)	Sensitivity (%)	Specificity (%)	The Sorensen-Dice (%)	Jaccard (%)
I ₁ [11]	88,10	95,83	84,62	83,35	71,45
$I_{2}[12]$	79,46	71,44	81,02	52,22	36,26
<i>I</i> ₃ [10]	70,69	88,82	62,35	65,62	48,83
I ₄ [13]	81,92	98,19	71,90	80,31	67,10
[14]	81,51	65,95	88,38	68,60	52,21



Figure 3 - a) Original abnormal MRI image, b) denoised image, c) Laplacian filtered sharpened image, d) thresholded of the whole image, e) watershed segmented image, f) only tumor segmented, g) detected tumor.

218

MRI images	Accuracy (%)	Sensitivity (%)	Specificity (%)	The Sorensen-Dice (%)	Jaccard (%)
$I_1[11]$	92,16	74,84	99,97	85,58	74,79
I ₂ [12]	94,40	96,52	93,99	84,95	73,84
I ₃ [10]	95,06	92,52	96,22	92,18	85,49
$I_{4}[13]$	95,13	87,64	99,78	93,13	87,14
$I_{5}[14]$	90,88	70,73	99,78	82,61	70,38

Table 3 - Resulted Accuracy, Sensitivity, Specificity, the Sorensen-Dice and the Jaccard measurements.

7. CONCLUSION

Effective results for tumor detection and extraction are obtained by using algorithms following the first and third proposed methods. According to human vision, the quality, precision, and accuracy of the detected and extracted tumor appling algorithms from the first and third proposed methods are found to be better than the results given by the algorithm from the second proposed method. During the segmentation process, the internal structure of the image is preserved by applying the first and third proposed methods, and the location and area of the region of interest are accurately detected and extracted. The application of the second proposed method results in a detected and extracted region of interest whose edges are not preserved, as well as a lack of information about individual elements of the image and even parts of the surface in the internal structure of the image. Based on results obtained for accuracy, sensitivity, specificity, the Sorensen-Dice, and the Jaccard measurements, we can conclude that better results for tumor detection and extraction provide us with the first and third proposed methods.

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APPLIED INFORMATION TECHNOLOGY SESSION

A NOTE ON VEHICLE-TO-GRID SIMULATION FOR A SMART MICROGRID

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Abstract:

In recent years, the energy system and the environment have faced major problems. For this reason, electric vehicles (EVs) have attracted great attention in terms of energy systems and transportation. When EVs are evaluated together with the smart grid, they provide great gains such as energy security, promoting energy savings, reducing greenhouse gas emissions, and preventing air pollution. In this study, the operating performance of the microgrid-connected vehicle-to-grid (V2G) system consisting of household and industrial loads and renewable energy (solar, wind, and hydroelectric) generation was investigated. A total of 100 vehicles were considered in the V2G system, which has three different types of EV profiles. The system is modeled and simulated in MATLAB/Simulink. The effectiveness of V2G was evaluated in the simulation study. The simulation results show that V2G effectively regulates the grid voltage for a wide variety of inputs.

Keywords:

Electric Vehicle, Renewable Energy Sources, Smart Grid, Vehicle-to-Grid.

INTRODUCTION

The majority of the current global population lives in cities and this number is expected to continue to increase in the future [1]. However, different energy demands in urban areas of the world will continue to grow with increasing population. In recent years, the environment has been struggling with major problems due to greenhouse gases resulting from the combustion of fossil fuels [2]. This expected increase in energy demand will require new and innovative solutions for emerging problems [3]. While people in cities continue their daily lives, general trends in energy demand can be followed. While energy consumption tends to be high in business areas during rush hour morning traffic, the same situation can be observed in living areas during waking hours and just after people come home from work [4]. Considering this difference in energy demand over time, it is useful to evaluate it in terms of peaks and troughs. A sudden increase in energy demand causes a peak in consumption, while a sudden decrease in demand creates a valley. Overcoming these sudden increases and decreases in demand is one of the most important problems for electricity distribution systems [5].

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It can be very useful to offer solutions to reduce the irregularities between these hills and valleys. In the last quarter century, great attention has been paid to the solution of this problem in the world. Governments around the world provide incentives and devote a large portion of their national budgets to promoting the research and development of solutions to improve the world's emission levels [6]. One of the most important steps to be taken for a cleaner future is to reduce unnecessary energy use as well as reducing excessive consumption. One way to help would be to maximize the use of available energy by providing solutions to put the power held in reserve where it is needed. The electricity grids of the future, also known as Smart Grids, aim to assist these goals of modernizing energy management [7]. Smart grids are seen as a vital tool in tackling many of the problems we face with grid optimization and maintenance. EVs attract attention and are proposed as a solution due to their ability to reduce greenhouse gas emissions and fuel consumption, and increase sustainable energy use in transportation [2]. One of the most remarkable innovations that emerged as a result of this is V2G charging technology. This technology aims to return backup power to the grid when EVs are connected to a charger [8]. By doing this, it can benefit in reducing the imbalance between peak and valley in grid load. Existing studies on related topics are mostly conceptual and are just beginning to be applied to real systems.

The generation systems in the microgrid structure use renewable energy sources to meet the demand as much as the energy deficit. The integration of microgrid systems has many benefits for both power generation companies, consumers and power distribution companies. Integration of microgrid into grid; can increase the efficiency of the grid, reduce greenhouse gas emissions and reduce costs for consumers. EVs used as energy storage are generally recommended for intermittent sources since renewable energy generation is affected by weather conditions [9]. The idea of using EVs as energy storage facilitates their integration into renewable energy sources and microgrid. Because EVs are parked at work or home 22 hours a day; microgrid can treat EVs as an energy storage unit. EVs can consume and store energy, while generating power for the grid when parked and connected to the utility grid [10]. As EVs grow and the transition accelerates, charging units should become more common and charging times for EVs should be reduced. Reducing the charging time is important to popularize the use of EVs. However, this will increase the load on the power system. Therefore, the main goal for EVs is to reduce charging time and improve the power quality of the grid. [11].

In this study, the operating performance of the microgrid-connected V2G system, which consists of industrial and household loads as well as renewable energy (solar, wind and hydroelectric) generation, was investigated.

2. STRUCTURE AND FEATURES OF THE SIMULATION SYSTEM

EVs are used as a distributed power source for the grid in addition to being a controllable load [12]. In this study, it is aimed to transfer power from the V2G and at the same time to ensure optimum energy conversion in harmony with renewable energy sources. In this study, wind power plant (WPP), solar power plant (SPP) and hydroelectric power plant (HPP) were used as renewable energy sources. Unlike fossil energy sources, wind energy is a renewable energy source that does not cause any harm to the environment and can also be obtained with high efficiency. The WPP source, which produces electrical energy in direct proportion to the wind, produces a nominal power when the wind reaches a nominal value. However, if the wind speed exceeds the maximum wind speed value, the WPP will be off the grid until the wind returns to its nominal value. The WPP source used in this study is 4.5 MW. SPP systems convert solar energy into energy that can be used without causing carbon emissions. Carbon emissions occur during the generation of solar panels, which are only used in SPP systems. In SPP systems, the solar intensity follows a normal distribution and reaches its highest intensity at noon. The SPP source used in this study has a power of 8 MW. Another renewable energy source used in the study is the HPP system. HPP, which uses the potential energy of heightened water and converts it first into mechanical energy and then into electrical energy, has a power of 15 MW in this study.

The loads in this study; they consist of asynchronous machine and residential loads used to represent the effect of industrial inductive load on the microgrid. The residential load follows a consumption profile with a certain power factor. Asynchronous machine; it is controlled by the relationship between the mechanical torque and the rotor speed. The load power used in this study is 10 MW.

However, a fleet of 100 EVs with an average power of 40 kW was considered. A V2G system was created to have 3 different EV profiles. This groups are listed in Table 1. The average power for each vehicle was considered to be 40 kW. Thus, the total power of the V2G system is considered as 4MW. The fleet of 100 EVs in total is divided into three groups for ease of inspection according to different travel and charging times. It can be stated that if the charge rate of vehicle batteries is less than or equal to 85%, it is in the charging group, and if it is greater than or equal to 95%, it is in the regulation group.

- **Group 1**: Those who arrive at the workplace in a short time and have the opportunity to charge their vehicle at the workplace (30%) There are 30 vehicles in total in this vehicle group. The hours of 7:00-8:00 in the morning are taken as the departure time of the vehicles in the 1st group, and the hours of 17:00 and 18:00 in the evening are taken as the basis. Vehicles are traveling during these hours. During the rest of the day, they are in charging cases.
- **Group 2:** Those who reach the workplace in a longer time than the 1st group and have the opportunity to charge their vehicle at the workplace (60%) There are 60 vehicles in total in this vehicle group. Vehicles in this group travel for a longer period of time compared to the vehicles in the 1st group on their way to and from their workplaces.

Vehicles in this group, which are on the move between 6:00-7:00 in the morning and 17:00, 18:00 and 19:00 in the evening, are in charging position for the rest of the day.

• Group 3: Vehicles used in night shifts (10%) There are 10 vehicles in total in this vehicle group. Since the vehicles in this group work at night shift, it is assumed that they are at the workplace between 21:00 and 05:00, and that they are in the charging state for the remaining hours of the 24-hour period.

After the 100 EVs in this study were divided into three different groups according to their different travel and charging status, various examinations were made. By means of the three-phase contactor of the asynchronous machine in the settlement in the study;

- It was ensured that it was activated on 11:00 hour.
- A short circuit fault has occurred in the system within the [12:00-12:02] time interval.

When the system is in balance, it creates an extra load and its effect on the system is examined. The model discussed in this study is simulated for a 24-hour scenario. The general view of the system is shown in Figure 1.

Table 1 - G	roups o	of EVs.
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Group No	Group No Number of Vehicles	
Group 1	30	07:00-08:00/17:00-18:00
Group 2	60	06:00-07:00/17:00-19:00
Group 3	10	21:00-05:00



Figure 1 - Structure of proposed microgrid system.

3. V2G SYSTEM CONCEPT AND MICROGRID INTEGRATION

EVs offer many advantages such as increasing the efficiency of the charging system, reducing greenhouse gas emissions and dependence on oil. Also, the biggest advantage of EVs is to use technology known as V2G. The V2G application is basically a direct power flow from the vehicle to the distribution grid, which is applied only in the EV. With V2G, existing distributed energy storage devices are instantly available. With this concept, various applications of battery types enter the market. Two important connections are required in the implementation of the V2G concept: The first, the power connection used for the transmission of electrical energy from the vehicle. The second one, logic and control connections to give feedback signals when power is needed, in the direction the power is sent. When the EV has V2G implementation, it includes the following features: active power regulation, reactive power supply, load balancing, harmonic filtering, and reduction of operating cost and total cost of the system, improvement in load factor, emission reduction, monitoring of variable renewable energy sources, generating revenue. EVs with V2G system offer backup source for renewable resources. These features can provide ancillary services including frequency and voltage control, rotating reserve.

Reactive power compensation is one of the methods used to provide voltage regulation to the power grid. Reactive power support also provides power factor correction, reducing current flow in generation and power losses in power lines. Moreover, this service reduces the load on the power equipment, resulting in increased efficiency in the operation of the power system. In these cases, capacitive reactive power is required for power grid compensation. Grid connected EV can provide reactive power compensation service. The EV does not cause any degradation in battery life as active power compensation is provided by the DC coupling capacitor of the bidirectional battery charge. With the development and design of bidirectional fast charging stations, power compensation control is also provided in EV fast charging control. Active power compensation control controls the grid voltage during EV fast charging. Therefore, the grid voltage drop problem due to EV charging can be addressed with the proposed reactive power compensation control of the EV charging station.

4. SIMULATION RESULTS AND DISCUSSION

The system is modeled and simulated in MATLAB/ Simulink. If the state of charge (SoC) of EV batteries is less than or equal to 85%, it is considered to be in the charging group, and if the SoC is greater than or equal to 95%, it is in the regulation group. Here, the state of being in the regulation group; it is the case of using the batteries as a source by connecting them to the microgrid (SoC \ge 95%).

Thus, it means that EV battery groups will be used as a source in order to eliminate the problems that may occur in the grid such as power outage, voltage and frequency changes, supply-demand imbalances.

When a voltage drop occurs in the system, the system is activated and the EV battery can regulate the grid in order to return the voltage to the allowable limit range. The industrial load was activated at 11:00 by means of a 3-phase contactor. A short circuit fault occurred at 12:00.

Figure 2 shows the change in grid voltage. A decrease in the grid voltage was observed with the activation of the industrial load at 11:00 am. However, the system recovered and managed to bring the voltage back to the nominal level. In addition, although there was a critical change in the voltage in the short-circuit fault that occurred at 12:00, it reached the nominal value range in a short time. In Figure 3 (a) and (b), the active and reactive power values of hydroelectric, solar and wind power plants are shown, respectively. In Figure 4 (a) and (b), the active load power and total real power values are given, respectively. The change in regulation voltage is given in Figure 5 (a). As can be seen from the figure, a decrease in the regulation voltage was recorded at 12:00 at the time of the short-circuit fault. However, it is seen that the voltage value reaches the nominal value in a short time. A close view of this moment is given in Figure 5 (b). Figure 6 shows the number of EVs in regulation and charging, respectively, during the day. The vehicles in the regulation work in the V2G position. In the case of charging, it is understood that the vehicles switch to the load position.



Figure 2 - Change in microgrid voltage.



Figure 3 - (a) Active and (b) Reactive power values of energy generation units.



Figure 4 - (a) Active power values of the load and (b) Total real power values.



Figure 5 - (a) Change in regulation voltage (b) Close view of the change in regulation voltage.

5. CONCLUSION

With the increase in industrial and household loads, the energy demand is increasing day by day. The increase in the use of fossil fuels both causes environmental problems and causes the search for alternatives to these resources, whose reserves are about run out. In addition, the increase in energy demand brings along various problems such as low energy quality and power outage, voltage drop, etc. In this study, in order to solve these problems, a microgrid system with EV and renewable energy sources is discussed. When EVs are evaluated together with the smart grid, they provide great gains such as energy security, promoting energy savings, reducing greenhouse gas emissions and improving energy quality. In this paper, the operating performance of the V2G system connected to the microgrid consisting of domestic and industrial loads and renewable energy (solar, wind and hydroelectric) generation units was investigated. A total of 100 vehicles were handled in the V2G system, which has three different types of EV profiles. The system is modeled and simulated in MATLAB/ Simulink. The effectiveness of V2G was evaluated in the simulation study. The simulation results showed that V2G effectively regulates the grid voltage.

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AUTOMATIC ROAD EXTRACTION AND VECTORIZATION FROM SCANNED TOPOGRAPHIC MAPS

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Abstract:

The previous practice has shown that older editions of topographic maps of the Military Geographical Institute can be used as a reliable source of data in the process of creating digital topographic maps at a scale of 1:25 000. Since vectorization of the topographic data for the complete scale series of topographic maps has not been done, these maps are used exclusively in the form of raster services as a supplement to primary cartographic sources. Therefore, the large amount of data on these topographic maps can provide insight into how some phenomena moved and developed over time, but remained in raster form unsuitable for processing, analysis, and comparison with vector data obtained from primary cartographic sources and depicting the real character of some occurrences. The paper shows the process by which, using the Python programming language in combination with the ArcScan vectorization tool, line symbols of paved roads are extracted from the 1:25 000 topographic maps and then translated into a vector form suitable for further use. The data obtained in this way become available for multiple applications with a great saving of time, considering that the process is completely automated. A proposal for using the results through a comparison of the higher-order road network between the situation in 1969 and the situation in 2022 is given.

Keywords:

Object Detection, Automatic Vectorization, Scanned Maps Processing, Computer Vision, Image Processing.

INTRODUCTION

MGI is a scientific institution with a tradition of more than 140 years, whose current main activity is the production of topographic maps on a scale of 1:25 000. This map records 4 editions, so the I and II editions were made using the technological methods of the time in the period from 1947 to 1980 [1], while after 2002 it switched to the production of digital topographic maps (part III and IV edition). The transition from analog to digital production process happened with the III edition. The production process of the IV edition of the map (hereinafter DTM25) was established in the period from 2012 to 2015 [2] is still ongoing, and although the initially established digital techniques have proven themselves well in their beginnings, there is a justified need to improve the process in order to achieve faster and higher production as concluded in [3].

The aim is to implement digital image processing and object detection methods, machine learning methods, and advanced cartographic processing methods to upgrade the existing production process. Despite the progress of technological processes, the II edition of the topographic map 1:25 000 (hereinafter TM25), due to the rich content and accuracy of the data, still finds its application in the current production process as the main secondary source data. 2051 sheets were produced in this edition and it covers the entire territory of the former Yugoslavia [1]. In the period from 2002 to 2004, the translation of TM25 into digital form was started, by scanning map sheets. After scanning, georeferencing was performed in the national coordinate system within the seventh zone of the Gauss-Kriger projection (creation of *.tif and *.tfw files), and later in the UTM coordinate system [4].

The application of TM25 for the production of DTM25 can be viewed in two directions. The first one takes into account the obsolescence of TM25 and the differences in the content that are evident and uses them as a basis for an analytical-comparative overview of the changes in phenomena and infrastructure in relation to the state of content on DTM25, which is up-to-date. This argument is grounded in the idea that without additional processing, it is impossible to perform quantitative and geometrical analysis based on these maps [5]. This direction stems from the fact that TM25 is used in the form of a raster service, while the creation of vector content based on it for the entire area it covers was absent due to the orientation of human resources to the production of new topographic content for DTM25, rather than the vectorization of the TM25. Therefore, the analyzes in this manner were limited to small parts of the territory. The second concerns the application of methods of computer detection of objects and details on TK25 in raster form and obtaining vector spatial data that can be the starting point for creating DTM25 during 2D restitution. It must be borne in mind that the second approach is favorable for infrastructural contents that are less subject to changes such as facilities and communications. Both directions are based on some kind of detection from raster forms and the application of advanced methods of automatic vectorization.

While the application of machine learning methods for multiclass segmentation of raster maps [6, 7] is popular and practiced, this paper used a simpler color-based segmentation method known as the CIS method [7]. This paper will propose a methodology for the automatic vectorization of higher-order roads on TM25 sheets, representing the wider region of the city of Kruševac.

The focus is on roads that, according to their categorization, have great infrastructural importance, but do not tend to change over time, thus enabling additional application of this data. Machine learning methods and the application of CNN require extensive work related to preparing the training dataset, which, when it comes to topographic maps, directly depends on the symbology applied in the specific edition of the map. Although the best result of segmenting desired details from the map is expected to be obtained, any changes in the map's symbology mean that the trained model cannot be used for different editions. Therefore, it was decided that in the initial stages of research on data processing and extraction from these maps, it is good to address the problem of detail extraction through Computer Vision methods and color-based segmentation to lay a good foundation for further progress, but also for continued use of these methods when justified.

2. PRESENTATION OF COMMUNICATIONS AT TM25

In order to be able to explain how to detect graphic elements on a map, it is first necessary to explain the symbology of those elements. Geographic elements form the basic part of a topographic map - the map's geographic content [8]. Within them, communications are defined as objects that enable traffic. The elements of land, water, and air transport are shown on the topographic maps. Within land transport, railways and roads are distinguished. Roads can be further classified based on various characteristics. Thus, according to the type of pavement, modern (concrete or asphalt), macadam, and dirt roads meet.

In accordance with the instructions for making TM25 [9] highways, asphalt roads wider than 6 m and asphalt roads from 3 to 6 m can be classified as roads with modern pavement. What all roads with modern pavement have in common is that they are defined in the topographical key by a continuous line symbol in some shade of orange [10], but also that macadam roads are presented with a dashed orange line (Figure 1). As can be seen from the attached image, the symbol for the highway (a) and the asphalt road wider than 6 m (b) have identical shades of color, in contrast to the asphalt road from 3 to 6 m (c) and the macadam road (d). Although it does not belong to the group of modern roads, it is important to define the symbology of the macadam road for elimination in the later stages of processing. These color shades are mostly found only among these symbols, so they are suitable for extraction.



Figure 1 - Symbol for highway (a), asphalt road wider than 6 m (b), asphalt road from 3 to 6 m (c) and macadam road (d).

It is important to note that streets in populated areas are given a special symbol, but that symbol does not carry the information about whether a street is paved or not, but the criterion for its display is the fact that it connects two parts of the settlement. In case a modern road passes through a settlement, the symbol of the street is not drawn, but of the road [11]. In this way, it is possible to follow where the modern road passes through the inhabited place. The digital topographic key DTM25 is based on the topographic key TM25, so the symbology related to the roads has basically remained the same. It can be assumed that the asphalt roads shown on TM25 are also on DTM25, with a certain probability that the road from the category of asphalt road from 3 to 6 has been renewed and widened, and the road is wider than 6 m. It is also safe to assume that modern roads are located in the same position, with the fact that there may be a newly built road or fork in that area.

3. WORK METHODOLOGY

3.1. PREPARING TK25 FOR VECTORIZATION

The preparation of sheets for automatic vectorization is completely done using the Python programming language and the OpenCV library. The advantage of this approach is that in a very short time, a large number of sheets can be brought into a state suitable for further processing. The procedure begins by loading a georeferenced map sheet. From the map, it is necessary to eliminate all content that does not refer to modern roads. This includes other geographical elements of the map, such as hydrography, objects, vegetation and other elements, but also certain elements of communication, that is, roads whose pavement is made of materials other than asphalt or concrete. In more complex maps, the use of color information is essential for recognizing its features [12]. It has been observed that color is what distinguishes modern roads from other roads. Also, besides the roads, there is very little content on the map that is shown in the same color. These are mostly point symbols that denote objects (mostly religious - synagogues, monasteries, mosques).

The lower and upper limits of the pixel value whose range allows the extraction of orange details are determined empirically. Extracting content based on pixel values proved to be an acceptable solution. However, with this procedure, the macadam roads, which are represented on the maps with a combination of orange and white colors, as well as the mentioned dot symbols (Figure 2, marked with numbers 1 and 2) are retained in the images. The problem itself could be solved by adjusting the Gap Closure Tolerance parameter in ArcScan during later processing so that during vectorization the program does not vectorize lines that are at a greater distance than the set one. However, there are not rare situations where, due to the transparency of the map, in some cases, there is a slight overlap of elements. Then it can happen that a part of the symbol, the whole symbol or a textual printout (annotation) can be found on the communication symbol (Figure 2, marked with number 3). Water leaks are given in black color (Figure 2, marked with number 4). All types of bridges and overpasses on modern roads are represented by a combination of black and white colors (Figure 2, marked with number 5). All this leads to the creation of gaps in the array of pixels in the places where they are located. As some gaps are equal to or even larger than the orange sections of the macadam road, it is clear that only adjusting the Gap Closure Tolerance parameter will not give satisfactory results. There will be interruptions in the road network in places where there are larger overpasses or bridges, which in reality do not exist.



Figure 2 - View of the map segment (left) and the corresponding extracted imageroads (right) with appropriate markings.

The elimination of macadam roads and point symbols was performed by a combination of the Laplacian, find-Contours and contourArea functions from the OpenCV library. After detecting the contours of the roads and point symbols that have remained in the image, contourArea is used to calculate their areas. The area of contours that should not be in the image was determined experimentally. They are filled with white pixels and issued on a special mask. A mask with unnecessary contours is combined with an image containing only orange symbols, so only white pixels are transferred from the mask to the image. Through the assignment of a new value, the orange sections of the macadam roads and the dotted symbols are converted into white pixels. The procedure was necessary because if only the contours of small areas were erased and the corresponding ones left, the image would not be suitable for obtaining the desired results during automatic vectorization. After this part, the image is freed from unnecessary objects, but there are still gaps in the road network. These gaps were solved using dilation and erosion. Dilation and erosion are the basic morphological transformations, and they arise in a wide variety of contexts such as removing noise, isolating individual elements, and joining disparate elements in an image [13]. The number of iterations and the structuring element parameter were determined experimentally. A structuring element can be simply defined as a configuration of pixels on which an origin is defined, also called an anchor point [14]. In the case of dilatation, it is an ellipse, and in the case of erosion, a square is used. In this way, almost all the gaps were filled. The ones that remained were too far apart. If the number of dilation iterations or the structuring element were to increase, there would be a danger that close parallel paths would merge. A small number of those cases were solved by adjusting the aforementioned Gap Closure Tolerance parameter, but this time without the risk of gaps in macadam roads. Raster data prepared in this way are ready for automatic vectorization.

3.2. AUTOMATIC VECTORIZATION USING THE ARCSCAN EXTENSION

Above the previously processed raster map, a map of extracted roads is obtained, on which it is possible to perform automatic vectorization. The automatic vectorization process was performed within ArcGIS (version 10.5) software. First, binary raster reclassification was done using the Reclassify function. The binary classified image becomes the input data for the ArcScan extension within the software, which is intended for the processing and vectorization of raster data. ArcScan offers tools to convert scanned images into vector layers. An interactive vectorization experience to draw raster cells on a map to create vector features. The automatic vectorization experience requires feature generation for the entire raster based on predefined settings. As a large amount of geographic information still exists in the form of printed maps, a tool to integrate these documents into GIS is essential [12]. ArcScan provides an efficient way to speed up this integration process compared to traditional techniques, such as manual digitization. The ArcScan extension also provides tools that allow simple raster editing to prepare layers for vectorization. This practice, known as raster preprocessing, can help remove unwanted raster elements that are not part of the vectorization project. This is exactly what was done in this case in order to further clean up the resulting raster map and reduce the possibility of creating false vector data. On this occasion, all individual elements that are smaller than 50 pixels are deleted. Also, the vectorization style is set to be polygonal. It is important to address certain cases on the map with an adequate selection of parameters. As the topographical content is fitted and overlapped, and some elements are masked, it is necessary to pay particular attention to the Hole Size (value 5), Gap Clouse Tolerance (value 100) and Fan Angle (value 180) parameters in order to ensure that all holes, discontinuities (due to masking, the appearance of bridges and the like) and curves, which were possibly left

behind on the prepared rasters, were treated as a single road. In this way, the vector data of roads that are topologically correct were obtained, so each road segment was generated separately. The obtained data are raw because they represent the axis of the road, so exported in shapefile format (*.shp*) can be used for other purposes with subsequent definition of symbology as desired. The described process is shown in Figure 3.



Figure 3 - Workflow chart of applied methodology in work.

4. RESULTS AND DISCUSSION

4.1. DATA USED

The proposed methodology was applied to a sample of 8 TM25. The sheets refer to the territory of the wider region of the city of Kruševac. The selected sheets form a unit of four linked sheets of cards in two rows. The resolution of the scanned sheets is of the order of 4000×5500 pixels and 72 dpi. The state of the contents of the mentioned answer sheets in 1969.

Also, a comparison was made of the obtained data with the existing DTM25 data taken from the MGI *Central Geotopographic Database*, for the territory covered by these sheets, they were field checked and supplemented in the third and fourth quarters of 2022, so it can be concluded that they have a high level of credibility. During the field check of the contents of the topographic map, among other things, the type of pavement and the width of the roads are checked.

4.2. RESULTS OF ROAD VECTORIZATION

In accordance with introductory considerations, the purpose of such results can be multiple. As the territory of the sheets used for input data is already covered by the modern DTM25, a comparison of the state of the road network from 1969 and 2022 shown on the topographic maps will be presented here. Table 1 shows the length of the road network of asphalt roads from 1969 compared to the length of the road network of asphalt roads from 2022 according to TM25 sheets. The expected increase in the length of the road network can be seen, which is particularly noticeable on list 531-4-4 (Makrešane) where the length of the road network has increased by 315.85 %, and the least noticeable on list 531-3-1 (Medveđa) where this increase amounts slightly by 22%.

List nomenclature	List name	Asphalt roads 1969 (km)	Asphalt roads 2022 (km)	Difference (%)
531-3-1	Medveđa	55.7	68.5	22.98
531-3-2	Velika Drenova-sever	35.9	79.2	120.61
531-3-3	Trstenik	39.2	86.3	120.15
531-3-4	Velika Drenova-jug	51.2	91.8	79.30
531-4-1	Varvarin	32.3	82.3	154.80
531-4-2	Stalać	39.7	85.3	114.86
531-4-3	Kruševac	71.4	146.3	104.90
531-4-4	Makrešane	18.3	76.1	315.85

Table 1 - Showing the comparison of the length of the road network.

In general, various analyzes can be performed on the basis of this data. Calculating the density of the road network, comparing economic development with the density of that network or the structure of the roads are just some of the suggestions. A big advantage is that in a very short time, data can be obtained for entire districts, provinces or the entire country. For parts of the territory covered by all editions of topographic maps, they can be analyzed in more detail in terms of changes in the road network over time.

It should be determined whether there is justification for vectorizing other categories of roads from older editions of topographic maps. Macadam and packed stone roads, but above all dirt roads, have a huge tendency to change routes, destroying and creating new ones in short time intervals. This is particularly prominent in Vojvodina, but also in hilly and mountainous areas, mostly in eastern Serbia, where there are fewer and fewer people and the need to maintain dirt roads. Another additional obstacle when extracting all categories of roads using color-based segmentation methods is the fact that there are other linear map elements represented in the same or similar color, as stated in [7] and [15]. As a problem, this can manifest itself even more in the case of the extraction of lower order road categories, which in their composition have colors that are more similar compared to the other content of the map, e.g. dirt roads and grid lines.

4.3. POSITIONAL ACCURACY OF GENERATED LINEAR VECTOR DATA

Regarding the use of the obtained results as a starting point for the creation of a modern road network during the creation of DTM25, it can be concluded that the positional accuracy of the generated data is at a satisfactory level. This is based on the fact that after the georeferenced scanned map is processed, the newly obtained raster has the same image dimensions, so the accompanying files related to the spatial references of the original raster can be used to georeference the processed raster. It is important to note that the conclusion on positional accuracy is made in relation to the existing georeferenced topographic map, that is, the road representation on that map. When it comes to displaying roads on topographic maps, it must be emphasized that these data are cartographically modeled in accordance with the linear scale of symbols and positioned on the map according to certain rules. When the road extends directly next to a water surface or a railway line, due to the scale of the map it is impossible to provide all symbols with the same positional accuracy. In that case, water surfaces, then railroad tracks and finally roads, are given priority in more faithful positioning. It is an insight into the positional accuracy of the data obtained from the topographic map. From this, it can be concluded that the positional accuracy of the obtained roads cannot be higher than the positional accuracy of the roads on the map itself, from which the data is extracted. Another insight is reflected in the matching of the obtained vector data with the content on the georeferenced topographic map, i.e. the accuracy of the vectorized data in relation to the map of the extracted roads. Figure 4 shows map segments, extracted road segments, as well as the final vectorized data compared to the initial map.



Figure 4 - Presentation of methodology steps and positional accuracy of roads (Map segment – left, Road extraction map – Middle, Road vector data – right).

Certain deviations that can be found in certain parts arise as a result of the vectorization of lines that have experienced minor deformations in certain places due to dilation and erosion, as seen in Figure 5. Such cases are seldom and occur with sharp and short curves or when joining roads under small angles. Possible deviations occur at specific road breaks for the purpose of masking and fitting other cartographic content that cannot be addressed by selecting global parameters during vectorization. Also, at the junctions of modern and macadam roads where the beginning of the macadam road at the junction starts with an orange color, it is possible that a false detection occurred on a short segment.

5. CONCLUSION

As the production process of DTK25 is constantly being improved and supplemented with new technological solutions that emphasize an increasing part of the work related to vectorization is transferred from a manual to an automatic work process, with the aim that the obtained geotopographic material is of adequate quality, human resources are freed that are they can engage in other jobs. Also, the development of tools and methods of image processing and computer vision creates the possibility for using the vast amount of data, cartographic materials, and archival materials that have been generated over the long tradition of this institution. The challenge remains to find an approach to process these data so that they are usable for GIS analyses.

The method presented in this paper shows that today it is easier and faster than ever to get this data. It is also focused on several symbols within one geographical element of the topographic map content. When looking at the entire geographic content of a map, it is concluded that there are more thematic units of data that can be processed in similar ways. Topographic data obtained through this automatic process have adequate positional accuracy, and the method is scalable, making it possible to apply it to a large number of topographic maps, thus making the time required to obtain a vector road network corresponding to a past period negligible. The emphasis of the work is on data extraction, rather than on their application and analysis. During the development of the code, as with the vectorization itself, a large number of parameters for the functions used were tested in order to obtain optimal results that can be applied to all sheets.

Further improvements can be made in the domain of positional accuracy of individual parts of vectorized roads by considering the use of an even larger number of parameters and the effectiveness of deep learning methods and training dataset preparation.

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ROBOT MOVEMENT PROGRAMMING FOR FLEXIBLE CELL IN "OPEN CIM SCREEN"

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Abstract:

Industrial robots have become an important part of every technical institution. The experiment was held on the flexible manufacturing cell for robot movement and cell control. The executed robot movements are transferred to the software for the model used called SCORBASE. The software is able to control the entire flexible cell, including the robot movement, the control of the machine door and the clamping device, and the transport of the parts with pneumatic feeding. The robot is mounted on a mobile axis, which allows additional movement of the robot, as the robot is located in a flexible cell with two machines (CNC Mill and CNC Lathe) and pallets for picking up and placing objects.

In this paper, the movement of the robot in its workspace is described using the positions created with the teach pendant device for manual robot movement. These stored positions are used to program part priorities for transferring individual parts from the part feeders to the machine for the manufacturing process and then back to the pallet for the finished parts. The part priorities described in this paper are used to supply machines with six parts, four parts on the CNC lathe and two parts on the CNC Mill.

Keywords:

Robotics, Artificial intelligence, Programming, Automation, Education.

INTRODUCTION

Flexible manufacturing cells are integrated manufacturing systems that consist of processing machines and automated systems for workpiece manipulation. A flexible manufacturing cell is used to machine one type of machine part. When a product is changed, the entire cell must be changed in terms of the arrangement of the machines, the automated systems, and the programs with which this cell operates. It is necessary to machine six workpieces according to certain priorities: Four on the CNC lathe and two on the CNC mill. Depending on the priority, the robot picks up the workpieces from a pneumatic or a gravity feeder. In the pneumatic feeder, the parts are prismatic while in the gravity feeder the parts are cylindrical. The robot inserts the workpiece into the machine and waits until the machine has finished the process. After processing, the robot takes the processed part out of the machine and places it on the pallet place.

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e-mail: pjakovljevic51@gmail.com The robot is programmed on two computers using SCORBASE software for Scorbot ER - 4. The first computer is used for programming the part priorities, while the second computer is responsible for moving the robot, activating the part feeder, opening and closing the machine doors, and opening and closing the machine clamps [1].

2. CELL SPECIFICATION

A flexible cell on which the process is carried out consists of (Figure 1):

- 1. Emco Concept 55 Mill;
- 2. Emco Concept 55 Turn;
- 3. Robot SCORBOT ER-4;
- 4. Robot mobile axis;
- 5. Pneumatic Feeder;
- 6. Gravity Feeder;
- 7. Palette for mill parts;
- 8. Palette for turn parts;
- 9. Computer for part priority programming;
- 10. Computer for Robot and cell control; and
- 11. Air compressor.

The robot is connected to two computers that have a program to control the robot and the entire flexible cell. The entire flexible cell is connected to a single air compressor that supplies compressed air to the machines for opening and closing the door and the clamps, and to

the pneumatic feeder for pushing the workpieces. The pneumatic feeder consists of a cylinder that is pulled out with compressed air. The cylinder pushes the part into the pick-up position. The parts are stacked on top of each other, when the cylinder returns the next part is ready to be pushed into the pick-up position. SCOR-BOT - ER 4 is an anthropomorphic configuration with 5 rotary joints. With the gripper attached, the robot has 6 degrees of freedom of movement [2]. This allows unrestricted positioning and orientation in a large working area. It has exceptional flexibility, reflected in its ability to avoid obstacles and enter inaccessible areas. It can move at high speed but has lower accuracy and variable resolution [3]. The cell is also equipped with a device called Teach Pendant. Teach Pendant is used to move the coordinate system of the gripper or robot joints throughout the workspace and save the positions in the SCORBASE software using the online mode [4], [5]. Online mode represents controlling the robot via cable connected device or manually guiding the gripper by hand.

The memory space in the robot controller is reserved for the definition of positions, so that recording positions is possible, which is defined using points, the number of points can be between 1 and 100. The points that define the robot positions are:

- 100-149 Movement towards the Mill;
- 150-199 Movement from the Mill;
- 200-249 Movement towards the Turn;
- 250-299 Movement from the Turn;



- 300-399 -Palette for finished Mill parts;
- 400-499 Palette for finished Turn parts;
- 500-599 Picking the parts from the Pneumatic Feeder;
- 600-699 Picking the parts from the Gravity Feeder
- 700-799 Movement on the mobile axis and
- 800-850 Waiting state.

3. ROBOT MOVEMENT AND CELL CONTROL

Planning the robot movement and controlling the cell operation is a complex and demanding task which can be solved in different ways [6], [7], [8].

To service the machines, the robot moves along the points on the mobile axis (700 - 799) to reach the pneumatic feeder for milling parts or the gravity feed for turning parts. After moving to one of the feeders, the robot opens the gripper, moves to the removal position, and removes the part (500 - 599) from the pneumatic feeder or (600-699) from the gravity feeder. The gripper closes and the robot returns to its position after moving to one of the feeders. The robot moves towards the machine (100 - 149) to the CNC mill or (200 - 249) to the CNC lathe, the machine door opens, and the gripper is released, the robot takes the position to place the part in the machine, then places the part in clamping device, waits two seconds for the clamping device to close and moves away (150 - 199) from the mill or (250 - 299) from the lathe.

The machine door closes and the robot returns to its position after reaching the machine. After machining the part, the machine door opens, the robot enters the machine work area, grips the finished part, the clamp releases and the robot returns to the position where it reached the machine. The machine door closes, and the robot moves to pallet 1 or pallet 2 and places the finished part on a pallet (300 - 399) for mill finished parts and (400 - 499) for turn parts.



4. PART PRIORITIES

After defining the points that the gripper must reach, it is necessary to define the priorities of the parts, based on the established priorities of the parts. The best way to manage the priorities is to create an algorithm based on which the robot movement is displayed according to the number of parts being processed [9].

Algorithm 1 checks if the CNC turn has produced three or more parts (Figure 2 on the left):

- Answer YES: The algorithm checks the state of the CNC Mill (algorithm 2);
- Answer NO: The algorithm asks if the CNC Turn is ready to accept the part.

Is CNC turn ready to accept the part:

- Answer YES: The robot places the part in the CNC Turn;
- Answer NO: Checking whether the CNC Turn is ready to remove the part (in case it has been previously processed).

Is the CNC Turn ready to remove the part:

- Answer YES: The robot removes the part from the CNC Turn;
- Answer NO: the cycle is completed and the CNC Mill is checked (algorithm 2).

Algorithm 1 is implemented as a part of the SCOR-BASE code in the provided example (Listing 1):

If TURN >= 3 Jump to MILL_CHECK
If PCTURN55_READY_TO_LOAD == 1 Jump to LOAD PCTURN55
LATHE _CHECK:
If PCTURN55_READY_TO_UNLOAD == 0 Jump to UNLOAD PCTURN55
Jump to CYCLE_END

Listing 1 – Algorithm 1.

Algorithm 2 checks if the CNC Mill has manufactured one part (Figure 2 on the right).

- Answer YES: A new cycle begins (algorithm 3);
- Answer NO: The algorithm checks if the CNC Mill is ready to accept the part.

Is the CNC Mill ready to accept the part:

- Answer YES: The robot places the part in the CNC Mill;
- Answer NO: The algorithm checks the condition of the CNC Mill.

Is the CNC Mill ready to remove the part:

- Answer YES: The robot removes the part from the CNC Mill;
- Answer NO: The cycle ends.

Algorithm 2 is implemented as a part of the SCOR-BASE code in the provided example (Listing 2):

MILL_CHECK: If MILL == 1 Jump to START1 If PCMILL55_READY_TO_LOAD == 1 Jump to LOAD PCMILL55 MILL_CHECK1: If PCMILL55_READY_TO_UNLOAD == 0 Jump to UNLOAD PCMILL55 Jump to CYCLE_END

Listing 2 – Algorithm 2.

Algorithm 3 checks if the CNC Turn produced four or more parts (Figure 3 on the left):

- Answer YES: The production of parts on the CNC Turn is finished and the state of the CNC Mill is being checked;
- Answer NO: Checking if the CNC Turn is ready to accept the part.

Is the CNC Turn ready to accept the part:

• Answer YES: The robot places the part in the CNC Turn;

• Answer NO: The algorithm checks the state of the CNC Turn.

Is the CNC Turn ready to remove the part:

- Answer YES: The robot removes the part from the CNC Turn;
- Answer NO: The cycle ends.

Algorithm 3 is implemented as a part of the SCOR-BASE code in the provided example (Listing 3): START1: If TURN >= 4 Jump to MILL_CHECK2 If PCTURN55_READY_TO_LOAD==1 Jump to LOAD PCTURN55 LATHE _CHECK1: If PCTURN55_READY_TO_UNLOAD==0 Jump to UNLOAD PCTURN55 Jump to CYCLE_END1

Listing 3 – Algorithm 3.

Algorithm 4 checks if the CNC Mill manufactured two or more parts (Figure 3 on the right):

- Answer YES: The cycle is complete;
- Answer NO: The state of the CNC Mill is being checked.

Is the CNC Mill ready to accept the part:

- Answer YES: The robot places the part in the CNC Mill;
- Answer NO: The state of the milling machine is being checked.

Is the CNC Mill ready to remove the part:

- Answer YES: The robot removes the part from the CNC Mill;
- Answer NO: The cycle ends.

Algorithm 4 is implemented as a part of the SCOR-BASE code in the provided example (Listing 4):

MILL_CHECK2: If MILL >= 2 Jump to ORDER_COMPLETED If PCMILL55_READY_TO_LOAD == 1 Jump to LOAD PCMILL55 MILL_CHECK3: If PCMILL55_READY_TO_UNLOAD == 0 Jump to UNLOAD PCMILL55 Jump to CYCLE_END1



Listing 4 – Algorithm 4.

Figure 3 – Algorithm 3 and algorithm 4.

239
5. STATE DIAGRAMS

The state diagrams (Figures 4 and 5) represent the completed tasks of the robot in a unit of time. The symbol M represents the start of the program for tending the CNC Mill and the symbol T represents the start of the program for tending the CNC Turn.

The diagrams show that the robot spends the least amount of time removing parts from the feeders. This is because the parts to be removed are not placed in the fixture, but are already on the removal rack, so the robot can quickly remove a part from the rack without much precision or care if it collides with the fixture. The machine tending takes most of the time as greater precision is required. Another process that can take a lot of time is waiting for the machine to finish machining. The robot's waiting time depends on the part's priority and the part's machining time. A mistake can cause the part to fly out of the clamping device and damage the machine.



Figure 4 – State Diagram for Mill tending.



6. CONCLUSION

At the end of the flexible cell tending experiment, it can be stated that the flexible cell is working properly. There are a few problems with setting the priorities on the computer for partial priority. If one enters the value 0 or 1 in a certain line of the program, the program does not work, whereas if one enters the values 0 and 1 the program works. The advantage of the machine operation and control of a flexible cell is the control of the robot in real-time via the training device and the peripherals [10]. Controlling the robot in real-time via a training device can improve precision and make logical decisions for better control of the robot and the cell. Also, the ability to review the program, correct errors and control the robot through the program leads to the conclusion that the program can be executed online and offline. The online method is more recommended, as the robot's position can be viewed close up to avoid collisions with machines and peripherals.

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INFORMATION TECHNOLOGY IN SPORTS SESSION INVITED PAPER

SPONSORSHIP APPLICATIONS IN DIGITAL SPORTS MARKETING

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Abstract:

The dizzying pace of technology is causing radical changes in the sports industry. Sponsorship applications are also one of the areas where these great changes are experienced. Because of the digitalization of sponsorship practices, rights holders and sponsor brands need support from technology and software companies to communicate with the changing fan profile. Technology and software companies are involved in next-generation sports sponsorship in two ways. The first is to provide technical support to the rights holders and sponsor brands, and the second is to establish a sponsorship structure in which they are included. This research aims to determine the sponsorship practices of technology and software companies in the sports sector. The working group of the research consists of seven employees of the technology and software company which has an office in Istanbul. Content analysis technique has been used to analyse the data of the research. In line with the answers obtained from the content analysis, the themes of strategy, brand development and sponsorship, and sub-themes of these themes have been created. It has been concluded that technology and software companies collect useful data and create value by interacting with fans through sports sponsorship activities, they increase brand awareness among fans, they reach large audiences including fans and non-fans consumers by working with beneficiaries and co-sponsors, and they carry out digital marketing activities.

Keywords:

Digitalization, Marketing, Sponsorship, Sports.

INTRODUCTION

Technological developments provide easy access to information at an unprecedented speed. This situation causes the change in daily life and the transformation of business processes and its sectors in every field [1]. Sports sponsorship is also going through this transformation.

Sports sponsorship is a huge industry where brands reach large audiences and generate huge revenues. Traditional sports sponsorship requires long-term contracts between sponsoring brands and rights holders [2]. But digital tools have shaken the foundations of these deals. Sponsor brands and beneficiaries are now emerging with a different form of sports sponsorship that includes digital tools, digital journeys, digital fans and more [3,2].

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e-mail: oercan@sinop.edu.tr The transformation caused by digitalization encourages both rights holders and brands to use new methods to attract the attention of fans. The increasing pressure of digital tools on sports marketing causes this. With the digital evolution of sports marketing, the sports industry has understood the necessity of digital sports marketing in bringing both new fans and new investments to sports [4].

Experiencing digitalization in marketing is especially effective in sponsorship applications. Digitization shapes the interactions of rights holders, sponsor brands and their target audiences with each other in different ways from traditional sponsorship. For this reason, brands have to go beyond sponsoring sports events to succeed in today's sponsorship.

Brands need to approach their fans with new strategies to have a good sponsorship return. In the current period, fans prefer the brands which give them different experiences although they offer similar products or services. Digital sports sponsorship is the new way of communicating with fans and marketers need to focus on digital sports sponsorship. Digital tools assist marketers in this new understanding of sports sponsorship.

Thanks to digital tools, fan data is stored and databased fan interaction is provided [5,2]. Analysing data such as demographics, lifestyles, and personality traits of fans is only possible with digital tools. In addition, digital tools offer brands a convenient, easy and costeffective infrastructure for creating personal content.

Data, which is the beginning of a new trade in sports, is extremely valuable for sponsor brands. Two-way communication with fans is provided through this data. With analytical-supported applications, some movement areas are created for the fans, where the sports or sponsor can shape their practices, and then the digital footprints of these fans are followed. Various events and campaigns are organized to make sense of these footprints in the virtual world left by the fans. Instead of the billboards that were previously prepared to attract the attention of the fans, special contents are prepared for each of them [6]. At the end of the day, fans who think that they are valued and understood by the sponsor brands begin to sympathize with the sponsor brand [7]. In fact, the fans own the sponsor brand like the sports league, sports club or athlete they support.

Therefore, sponsor brands know how valuable the fan information obtained through digital tools is. Sponsors approach fans with more accurate and more effective marketing strategies thanks to the opportunities provided by digital tools. This is a great opportunity for them. They also use this data to measure and correct their own performance. Thus, they save time against other brands by creating key metrics that they can profit from.

Brands which carry their sponsorship to the digital world cannot carry out these data and data-based processes by themselves. For this reason, the marketing units of most sponsor brands work with technology and/or software companies that are suitable for them and their sponsor rights holders. Recognizing the potential of sports sponsorship in the global market, these technology and software companies, previously carried out the digital content and media works of sponsor brands in various sectors, now reveal their own sports sponsorships. Sports sponsorship has always been a profitable marketing area for brands in the sectors as food and beverage, clothing, transportation, communication, financial services, etc. It is not a coincidence that technology companies have turned to sports sponsorship with the digitalization of sports.

Only the sponsorships of technology companies are slightly different from the sponsorships of other sectors. Technology companies have a more 'dynamic' relationship with the rights holders they sponsor than brands from other sectors. In addition to placing their logos on stadiums, arenas or on athletes' sport wears, technology companies collect game/player data in the background and communicate with fans by providing services such as fan experience via digital tools. The increase in sports sponsorship partnerships of technology and software companies triggers transformations in sports marketing. Therefore, the presence of technology and software companies directly in sports sponsorship is a new research topic.

In this study, it is aimed to evaluate the opinions of the employees of one of the technology and software companies which has an office in Istanbul and carry out digital content and media sponsorship activities through sports. The research is a necessary and important research in terms of determining the place of sports sponsorship activities of technology and software companies recently involved in sports sponsorship in sports marketing.

2. METHOD

This study aims to reach the positive/negative results of the digital sports sponsorship activities of technology and software companies and uses phenomenology which is a qualitative research design for this purpose. Phenomenology focuses on experiences rather than objectively and physically described reality [8]. It concentrates on the facts that we are aware of but do not have an in-depth and detailed understanding of, which are frequently used in qualitative research [9]. Therefore, in this study, perceptions and phenomena are expected to be presented in a realistic and comprehensive way in their natural environments [9, 10]. Perceptions and meanings developed by the study group with their experiences about the phenomenon have been revealed.

2.1. WORKING GROUP

Criterion sampling method, one of the purposeful sampling methods, has been used in the study [10]. According to this sampling method, all situations are studied with a set of predetermined criteria [9]. The basic criterion to be used in the research; Employees who work as engineers in a technology and software company that sponsors digital sports. Information on the task variables of the participants are shown in Table 1.

2.2. DATA COLLECTION

The data of the research have been collected from the people working in a İstanbul based technology and software company. Interviews have been held between 03-06 March 2023 by video conference method. In this study, the data have been obtained with a semi-structured interview form developed by the researcher via video teleconference. The data obtained from the interviews have been recorded in the computer environment. To obtain comparative answers, the questions in the form have been prepared after field survey and expert opinion. In the interviews, six (6) semi-structured openended questions have been asked. These questions have been determined for digital sports sponsorship activities. The questions have been prepared by the researcher herself and care has been taken to ensure that they were easy to understand and not directive for the participants.

Interview questions have been directed to each participant using the same words. The data obtained from the interviews have been recorded with a voice recorder. 62 pages of data have been obtained from the analysis of the interviews. The data have been written down and their accuracy has been ensured.

2.3. VALIDITY AND RELIABILITY

In the study, credibility, transferability, consistency and confirmability strategies used in qualitative research have been used for validity and reliability [9, 10]. Long time interaction, expert review and participant confirmation strategies have been used to ensure credibility in the research. To strengthen the interaction between the participant and the researcher with long-term interaction, attention has been paid to create an environment of trust by keeping the interview times long. With the expert review, opinions about the research have been obtained from people who have general knowledge about the research subject and who are experts in the field of qualitative research methods. Purposeful sampling has been chosen to ensure transferability in the study. For consistency, Miles and Huberman's (1994) "Agreement / (Agreement + Disagreement)" formula has been used [11].

Participant	Duty	Participant Code
M1	Software Engineer	YM
M2	Network Engineer	AM
M3	DevOps Engineer	DM
M4	Python Engineer	РМ
M5	Site Reliability Engineer	SGM
M6	Simulation Engineer	SM
M7	Personnel Engineer	РМ

Table 1 - Distribution of Employees by Duty Variable.

2.4. ANALYSIS OF DATA

Content analysis technique has been used in the research. The data obtained from the audio recordings have been transferred to the computer environment. Then, it has been analysed and interpreted with the Nvivo 10 package program. In the research, the data have been analysed using descriptive and content analysis methods. According to the descriptive analysis approach, the obtained data are summarized and interpreted according to the determined themes [9]. In descriptive analysis technique; data reduction, presentation and conclusion steps are followed [12]. For this reason, the data obtained from the participants have been transferred to the computer environment, coding has been made and themes have been created. Details on the themes are presented in Table 2.

As seen in Table 2, there are three themes and subthemes in the study. These themes and sub-themes have been interpreted with a descriptive narrative. The directly quoted opinions of the participants are given in italics and their codes in parentheses.

3. FINDINGS

The Participant opinions have been transferred by coding without giving names, depending on the principle of confidentiality. In line with the interviews with the participants, the following findings have been reached.

As seen in Table 3, the participants have stated that digital strategy and social media strategy have been used in the sports sponsorship activities of their companies. Participants have stated that while implementing the digital media strategy, they have brought together the rights holders, media platforms and fans and they have seen themselves as a part of this sponsorship (YM, PM, DM). One of the participants, YM, has stated that "With the digitalization of sports, technology companies like us provide the communication between rights holders and sponsors", while DM has said, "We are the newest actors in sports. Sports sponsorship is a good way to quickly introduce ourselves to large audiences". Participant PHM has stated that "We shape the data for our own benefit as we assume the responsibility in the sponsorship agreements made". SGM, on the other hand, has stated that "The fact that e-sports is digital on its own makes us turn to sports sponsorship".

Table 2 - Content Analysis Themes.

	CONTENT ANALYSIS THEMES	
THEME 1	THEME 2	THEME 3
STRATEGY	BRAND DEVELOPMENT	CREATING CONTENT
Sub Themes	Sub Themes	Sub Themes
Digital Strategy	Data Cleanroom	Adopting Technology to Fans
Social Media Strategy	Data Collaboration	Improving the Fan Experience
	Value Creation	Sharing Technology with Joint Sponsors
		Obtaining Other Income Sources in addition to Technology Services

- ····································	Table 3 - O	pinions of l	Participants on	Strategy Develo	pment.
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Components	General Statements Determined in the Interview				
Digital Strategy	We bring together brands, rights holders, media platforms and fans. We include ourselves in these partnerships (YM, PM, DM). Sports sponsorship is the right strategy for new markets (PHM, SGM, DM, AM, PM).				
Social Media Strategy	<i>We determine how the fans experience our company in the digital environment together with the brands (SM, DM, YM, AM).</i>				
	We bring together new social media tools with beneficiaries (PHM, SGM, PM, DM).				

Regarding the social media strategy, the participants have stated that while determining how the fans have experienced the sponsor brands in the digital environment through social media, they have also determined their thoughts about their own companies (SM, DM, YM, AM, PHM). They have also expressed the opinion that they have provided the use of new social media tools and implemented sports sponsorship in this new social media. SM has said, "The fact that fans follow sports on social media causes the popularity of social media to increase even more. We also design our sponsorship activities in a more visible way on social media." YM has stated that, "We increase our sponsorship value, both of other sponsors and our own, with social media tools". PHM has said, "We make athletes more visible on social media rather than sports clubs. Fans mostly enjoy interacting with athletes. Athletes often get ahead of clubs in sponsorship."

As can be seen in Table 4, the participants' views on brand development are creating the data cleanroom, data collaboration, and value creation. According to the opinions of the participants, the data of the fans have been shared with other stakeholders after their trust is established. For this reason, a data clean room has been created. Data sharing with beneficiaries and co-sponsors has been controlled (AM, YM, SGM, PM). AM, one of the participants, has used the phrase, "It is one of our company's policies to approach data sensitively." PM has said, "We have created a data clean room especially against cyber-attacks. The data cleanroom has increased the confidence of fans in us, our beneficiaries and our co-sponsors."

Participants have stated that after storing the data, they have shared it according to the needs of rights holders and other partners. They have stated that they have also benefited from these data for their own sponsorship activities. One of the participants, DM, has said, "We analyze and license the data we collect in the data clean room. We sometimes combine this data with sports sponsorship and include it in our strategy against our competitors."

The participants have stated that they create value by gaining the trust of the fans. PM has said, "As a technology and software company, the fans are more comfortable moving and sharing because they know that we are on the field".

Table 5 shows the opinions of the participants regarding the sponsorship activities of their companies in sports. The participants' views on sponsorship activities includes adapting technology to fans, improving the fan experience, sharing technology with joint sponsors, and obtaining other income sources in addition to technology services.

Table 4 - Opinions of Participants on Brand Development.				
Components	General Statements Determined in the Interview			
Data Cleanroom	We share data with sponsors and rights holders (AM, YM, SGM, PM) without damaging the trust of the fans.			
	When we make data available for permission, we build trust among fans for our company as a brand (PM, SM, YM).			
Data Collaboration	We share data with beneficiaries and partners according to their needs (DM, PHM, YM).			
Value Creation	We believe we can make a difference. We want to be valuable in the eyes of the fans (AM, YM, PM, SM).			
	Sports sponsorship is a platform where technology and innovations can be used comfortably (YM, SGM, PHM, PM).			

Table 4 -	Opinions of	Participants on	Brand Development.
	1	1	1

Table 5 - Opinions of	Participants on	Sponsorship	Activities
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Components	General Statements Determined in the Interview
Adapting Technology to Fans	Fans adopt technology more quickly in sports (PHM, YM, AM, PM, SM).
Improving the Fan Experience	We constantly test our company's capabilities with the feedback we receive from fans (SM, PM, YM, DM, PHM).
Sharing Technology with Joint Sponsors	<i>We work in coordination with other sponsors. We follow the digital footprints of the fans who turn to them (PM, AM, YM).</i>
Obtaining Other Income Sources in addition to Technology Services	Apart from the technical services we offer through sponsorship, we ensure to be visible like other partners (SM, PM, DM).

One of the participants, PHM, has said "The fans who consume the digital products we offer sometimes become a part of the solution". Concerning the improvement of the fan experience, participant SM has stated that "Because the use of content and data is more in sports sponsorship, it is necessary to act more carefully". AM has stated about the technology sharing with cosponsors that "We connect with other sponsors through our sponsorship. We even store the data of their other consumers". Regarding income sources in addition to technology services, PM has declared that "Some of the fans also demand technical services from us for their own businesses".

4. DISCUSSION AND CONCLUSION

Digital technologies are causing major changes in the way sponsorship is practiced. During the transition from traditional sponsorship to digital sponsorship, all brands compete to impress their fans with digital technologies. Digital sports sponsorship allows brands to accurately target their campaigns, realize the fan experience, and measure the commercial impact of their sponsorship practices. It offers brands a unique opportunity to grow through digital sports sponsorship.

With the evolution of sports into digital, technology and software companies have started to take part in the new generation sports sponsorship with their own brands after realizing that there is a potential to earn more money through sports. Sports sponsorship is one of the cornerstones of digital sports marketing, and sports sponsorship practices of technology and software companies directly affect digital sports marketing. Therefore, according to the findings of this research, which aims to reveal the opinions of technology and software company employees about sports sponsorship, the following conclusions have been reached:

- Digital sports sponsorship is an important area for technology and software companies to find new markets and increase their awareness. In this way, they reduce time and advertising expenditures and gain an advantage over their competitors.
- 2. Digital and social media environments where fans interact with sports leagues, sports clubs or athletes that they admire, greatly contribute to the marketing and sponsorship practices of technology and software companies. In particular, fully digital e-sports have unlimited opportunities for technology and software companies to achieve their sponsorship goals.

- 3. Technology and software companies can easily show their talents/capabilities to fans, beneficiaries and co-sponsors through sports marketing and sports sponsorship. They can build trust among fans against their brand. In this way, they get useful data from fans.
- 4. They provide insights to co-sponsors based on data from fans. In this way, co-sponsors have the opportunity to access the data of their consumers outside the scope of sports sponsorship.
- 5. Thanks to the data obtained from sports sponsorship, they can create an admiring target audience, just like the rights holders, by using advanced technologies.

Finally, it is concluded that sports sponsorship is a profitable marketing activity for the technology and software companies. The technical assistance needed for the intervention of digital tools in marketing and sponsorship activities and the use of these tools in marketing shows that technology and software companies will take more place in sports sponsorship practices.

The limitations of this research are that the sample group consists of technology and software company employees. In future studies, including more technology and software companies in the sample, conducting similar research on the rights holders, co-sponsors and fans they sponsor are important to understand the place of technology and software company sponsorships in digital sports marketing.

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SINTEZA 2023

PSYCHOMETRIC PROPERTIES OF ONLINE VERSIONS OF MENTAL TOUGHNESS QUESTIONNAIRES IN BASKETBALL PLAYERS

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Abstract:

The aim of this study was to examine the psychometric properties of using the online version of the questionnaires for assessing mental toughness to gather and analyse the data in scientific research. It was assumed that, with the right introduction, written explanation, and usage of available IT solutions the results will have good psychometric properties.

The sample of 79 male athletes that played basketball in a 2022/2023 season, filed online version of the Sports Mental Toughness Questionnaire (SMTQ), the Psychological Performance Inventory - A (PPI–A), and Mental Toughness Inventory (MTI).

Results of descriptive analyses showed that good metric characteristics and discriminativeness of all three instruments. Reliability was also confirmed with obtained Cronbach's alpha coefficient scores. Obtained low to high significant positive correlations among all scales and subscales confirmed construct validity of online versions of all three questionnaires for assessing MT.

It was concluded that further research of this way of using of measuring instruments is needed but also justify.

Keywords:

Online platforms, Online questionnaires, SMTQ, PPI-A, MTI.

INTRODUCTION

In competitive or stressful professions like police work, military, medicine, sports, business etc. often the difference between successes and failure is a split-second decision taken under a certain amount of psychological pressure [1, 2]. How a person behaves in those tense situations and in a prolonged challenging environment is determined by individual characteristics that are often attributed to the concept of Mental Toughness (MT) [3]. The term itself, mental relating to the mind, or involving the process of thinking [4], and toughness as a noun describing something strong, not easily broken or made weaker or defeated [5], represents a concept that a certain set of personality characteristics define how a person reacts and deals with stress and challenges. MT is defined as a personal capacity to produce consistently high levels of subjective (e.g., personal goals or strivings) or objective performance (e.g., sales, race time, GPA) despite everyday challenges, stressors and significant adversities [6].

In sports, especially at the professional level where people's jobs and careers are at stake, stress is an important and ever-present factor that can affect not only one performance, but the whole season or career [7]. Psychological burdens are present daily as a continuity in a quality performance, both in a practice and in a competition, is expected and needed. Some athletes fare better, cope better with stress, have more stable performances and have better results in general, so the connection between Mental Toughness and performance in sports was made [8]. It is easy to see why that is so. While playing basketball, players constantly have to make decisions, in less than a second, while running full speed, and while engaged in physical contact with the opponent, that can affect the course of the game and the final result. Plus, the training process is long and stressful and many people can't handle the pressure. Over the last couple of decades many studies were conducted to measure the importance and the link between sport results and MT. For example, the results of recent studies suggest that MT of young female basketball players played a significant role in performance index rating [8]. The benefits of discovering and defining a personal characteristic that can predict success would be enormous in terms of recruiting and selecting the candidates and that is why most studies regarding MT was done within sports context and even when it was examined in non-sport contexts, scholars have applied sport models with little explanation of the substantive or empirical evidence for doing so. Besides that, MT is still a controversial topic regarding the fact that, even with all the research done there is still a problem with its conceptual clarity, dimensionality (is it a multi or unidimensional concept) and traitress, (unresolved yet substantively important issue is whether MT is best conceptualised as a dispositional, trait-like or situational, state-like construct) [6]. Reflecting this range of different definitions, insufficient effort has been devoted to the development of a reliable and valid measure of mental toughness in sport [9]. Most of the studies were conducted by a questionnaire designed for a self-valuation process that would use the results and place them on a scale measuring the construct [7]. The scales mostly used are usually the Likert 5- or 7-point scales, in which 1 is false 100% and the biggest number (5 or 7) represents the opposite and 100% true, while the numbers in between represent the claims slowly graduating from one statement to another. The construction of the Likert (or Likert type) scale is rooted in the aim of the research. Sometimes the purpose of the research is to understand the opinions/perceptions of participants related with single 'latent' variable phenomenon of interest). This 'latent' variable is expressed by several 'manifested' items in the questionnaire [10]. For example, by agreeing or disagreeing with the statements like "I laugh a lot" regarding humour, and "I am always committed and involved" regarding sense of purpose, the person is actually answering the question of happiness and subjective well-being. [11]

Before the COVID-19 pandemic these types of questionnaires where done in person and were written on paper [12], with the advantage of the person doing the research, being present to explain and guide the process. Online environment and transdisciplinary attitude were needed to develop scientific research, given the complex societal challenges we faced during pandemic [13]. Sample collection via online platforms, which during the pandemic was practically the only safe way to conduct large-scale research, turned out be very practical and simple in practice. Major strengths of the online survey are: global reach, business-to-business (B-to-B) and business-to-consumer (B-to-C) appeal, flexibility, speed and timeliness, technological innovations, convenience, ease of data entry and analysis, question diversity, low administration cost, ease of follow up, controlled sampling, large sample easy to obtain, control of answer order, required completion of answers, go to capabilities, knowledge of respondent vs. nonrespondent characteristics, while the major potential weaknesses are: perception as junk mail, skewed attributes of internet population: upscale, male, etc., questions about sample selection (representativeness) and implementation, respondent lack of online experience/expertise, technological variations, unclear answering instructions, impersonal, privacy and security issues, low response rate [14].

In sport particularly, having in mind busy competition calendar, time needed for training as well as for rest, traveling all around the world for matches and training camps, it is difficult to gather representative samples for the research. Online solutions may be the answer, but the question arises as to how valid this method of conducting research can be, given that majority of the questionnaires of Mental Toughness (as well as majority of other similar psychological instruments) are intended to be filled in with the physical presence of the examiner (psychologist). On the other hand, companies dealing with psychological assessment, such as AQR International, are developing online solutions for the application of their instruments, which is why, the online version of their mental toughness assessment questionnaire MTQ was available for online assessment even before the pandemic.

The aim of this study is to examine the psychometric properties of using the online version of self-report instruments for assessing MT to gather and analyse the data in scientific research. We assumed that with the right introduction, written explanation, and usage of available IT solutions the results will have good psychometric properties, which is first condition for thinking of implementation of such solutions in research practice. It is important to note, that this approach doesn't mean that the role of psychologist in conducting psychometric assessment should be changed. We just want to examine possibilities of implementation of online IT solutions in this process, as it happened in numerous other fields during and after pandemic.

1.1. PARTICIPANTS

The sample for this research was 79 male athletes that played basketball in the 2022/2023 season, divided in two basic categories, Serbian speaking and non-Serbian speaking. Non-Serbian speaking participants did an English version of the questionnaire, while the Serbian language speakers did the Serbian translation. Serbian language form was filled by 54 participants (age = 21.6 \pm 4.9) from 9 different clubs, in three different divisions (14 participants played 1 division in the season 22/23, 14 second, and 28 third division). 14 od the 54 still had a junior status while 40 of them were seniors, with sports experience (number of years playing the sport) on average of 11.7 \pm 5.5 years. 21 of them are elite athletes while 33 of them never had any national team experience. By playing position in the team, 14 of them were point guards (1), 12 shooting guards (2), 11 small forwards (3), 11 power forwards (4), and 5 of them were playing centre (5) position. English form was filled by 25 participants (age 18.6 \pm 5.0) from 3 different clubs, 11 cadets, 6 juniors, 8 seniors with an average sports experience of 9.3 \pm 4.8. 3 of them played first division, 9 of them played second division and 13 of them played third division during the 22/23 season, while 8 of them were elite athletes and 17 had no national team experience. By position in the team, 4 of them were point guards (1), 7 shooting guards (2), 4 small forwards (3), 6 power forwards (4), and 4 of them were playing center (5) position.

1.2. MEASUREMENTS AND PROCEDURES

For this study we used the Google Forms to collect and analyse the data. Google Forms allows us to compose questions, collect answers from respondents, and present data in spreadsheet format so that participants can track and analyse the data using Google Sheets. [15] In this study the participants were filling the form at the time of their choosing, in the privacy and comfort they chose, mostly using their phones, just by clicking on the link sent to them by their coach. This is not a standard environment for a study like this witch raises the question of validity of the results. But Google Forms is a 100% free to use web-based survey tool that offers unlimited surveys with unlimited respondents where survey answers and data are automatically collected in Google Spreadsheets, has the option to embed a survey into emails or websites, gives lots of theme options, add your custom logo, photo or video option, and add collaborators option, with only limitation in data privacy, [16] and as such has a great potential for this type of studies, thus the attempt to validate the results. Moreover, as web-based surveying offers researchers many advantages over more conventional survey modes, these findings suggest that non-market valuation practitioners should consider using this survey administration mode in the future. [17] For our study we chose Google Forms because the Google Forms provides various options for capturing the data from multiple answers. For example, one can have multiple choice options, check boxes, scale, grid, text, etc. [16].

Absence of personal presence of the examiner (psychologist) is the biggest problem in this kind of research. It can be potentially overcome with usage of filmed explanations posted on video sharing platforms and a linked to an online questionnaire, or his/her live online presence during data gathering sessions with help of platforms such are Google Meet, Microsoft Teams or similar. Because of explorative nature of this study, we didn't apply this kind of procedure, wanting to know whether the application of the online questionnaire without built-in security mechanisms that would ensure greater validity affect metric characteristic of the instruments.

After data gathering, all the procedures of the data processing and interpretation were done by the psychologist as it would be done if the traditional paper and pen version was used.

1.3. STATISTICAL ANALYSES

The online questionnaire was set in a way that does not enable existence of missing values or multiple answers, which enabled the analysis to be carried out immediately after data collection. First, the data were subjected to descriptive statistical analysis. Minimum, maximum, mean, standard error of mean, standard deviation, coefficient of variation, skewness as well as kurtosis was calculated. The Kolmogorov-Smirnov nonparametric test was used to determine the normality of the data distribution. Reliability analysis was used to determine the reliability of the instruments. Cronbach's alpha score and Cronbach's alpha score based on standardised items was calculated. Construct and convergent validity were tested with Spearman's nonparametric correlation test. For discriminant validity assessments descriptive statistics, skewness and kurtosis as well as nonparametric Kolmogorov-Smirnov test were used.

Statistical significance was defined at the level of 95% probability, for the value of p < 0.05 and at the level of 99% probability, for the value of p < 0.01. All statistical analyses were performed using SPSS 20 (IBM Corp., Armonk, N.Y., USA) and Jamovi (version 1.2.27.0).

2. RESULTS

Descriptive statistical analysis was performed on the whole sample for the total scores as well as for the scores on subscales (Table 1) of the SMTQ, PPI-A and MTI. Standard error of mean ranging from 1.37% (SMTQ) to 2.37% (Control) of mean enables accurate and narrow

estimation of the population mean. The analysis shows that the sample was quite homogeneous on all of the variables and with an acceptable coefficient of variation. Descriptive statistics and the Kolmogorov-Smirnov nonparametric test showed there are no significant deviations from the normal distribution except Constancy, Determination, and MTI.

The analysis of the observed deviations of the distributions was done with the Q-Q plots (Figure 1). The presence of outliers at lower scores as well as accumulation in maximum values can be observed in all three distributions. The elimination of outliers, first of all, with the possible application of logarithmic transformation, which is unnecessary in this particular case, would lead to the elimination of observed deviations and enable the application of parametric statistics in further analyses. Considering the specific goals of this work, this will not be the case, but further analyses will be done on the original data and scores.

Reliability analysis (Table 2) was performed at the level of individual answers of respondents on all items of both total scores and subscales of the SMTQ, PPI-A and MTI, on the total sample. Obtained Cronbach's alpha scores prove to be excellent for MTI, good for PPI-A and Determination, acceptable for SMTQ, Self-belief, Positive Cognition as well as questionable for Confidence, Constancy, Control and Visualisation.

	Minimum	Maximum	Mean	SEM	Std. Deviation	COV	Skewness	Kurtosis	Kolmogorov- Smirnov Z
SMTQ	2.36	4.00	3.01	0.04	0.36	0.12	0.17	-0.51	0.79
Confidence	1.67	4.00	2.85	0.06	0.51	0.18	-0.33	-0.39	1.15
Constancy	2.00	4.00	3.40	0.05	0.48	0.14	-0.86	0.23	1.62*
Control	1.50	4.00	2.87	0.07	0.60	0.21	-0.24	-0.53	0.99
PPI-A	2.64	4.93	3.94	0.07	0.59	0.15	-0.32	-0.67	0.74
Determination	1.67	5.00	4.16	0.09	0.82	0.20	-1.04	0.40	1.88*
Self-belief	2.00	5.00	3.84	0.09	0.77	0.20	-0.18	-0.92	1.06
Positive Cognition	2.00	5.00	3.93	0.08	0.68	0.17	-0.44	-0.12	0.95
Visualization	2.00	5.00	3.87	0.09	0.76	0.20	-0.24	-0.75	1.11
MTI	2.25	7.00	5.59	0.13	1.15	0.21	-1.11	0.84	1.46*

Table 1 - Descriptive statistics for the SMTQ, PPI-A and MTI scores.

* Significant at the 0.05 level



Figure 1 – Q-Q plots for Constancy, Determination and MTI scores.

Cronbach's a	Cronbach's a Based on Standardised Items	N of Items
0.701	0.715	14
0.684	0.693	6
0.610	0.616	4
0.637	0.652	4
0.862	0.869	14
0.805	0.805	3
0.716	0.733	4
0.731	0.731	4
0.630	0.646	3
0.928	0.929	8
	Cronbach's α 0.701 0.684 0.610 0.637 0.862 0.805 0.716 0.731 0.630 0.928	Cronbach's α Based on Standardised Items0.7010.7150.6840.6930.6100.6160.6370.6520.8620.8690.8050.8050.7160.7330.7310.7310.6300.6460.9280.929

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Table 3 - Correlation analyses for the SMTQ, PPI-A and MTI scores.

	Conf.	Const.	Cont.	PPI	Det.	Selfb.	Pos.Cog.	Visu.	MTI
SMTQ	.828**	.633**	.568**	.577**	.360**	.477**	.535**	.387**	.524**
Confidence		.350**	0.180	.420**	.296**	.279*	.424**	.282*	.433**
Constancy			0.177	.465**	.453**	.265*	.415**	.323**	.422**
Control				.339**	0.016	.483**	.285*	.256*	0.159
PPI-A					.732**	.773**	.849**	.776**	.795**
Determination						.333**	.531**	.556**	.709**
Self-belief							.599**	.400**	.551**
Positive Cognition								.560**	.683**
Visualization									.560**

** Correlation is significant at the 0.01 level (2-tailed), * Correlation is significant at the 0.05 level (2-tailed).

Spearman's nonparametric correlation analysis was performed on the whole sample for the total scores as well as for the scores on subscales (Table 3) of the SMTQ, PPI-A and MTI. Among all scales and subscales, low to high significant positive correlations were obtained. Confidence is which doesn't correlate significantly Confidence, Constancy, Determination and MTI is an exception.

3. DISCUSSION

This study aimed to examine the psychometric properties of online version of the SMTQ, PPI-A and MTI in the population of basketball players. All the findings confirmed good psychometric properties of online versions of all three questionnaires in sport population, more precisely basketball players, making them candidates for further research of possibilities of implementation of IT solutions in domain of personality assessment, above all in scientific research.

According to descriptive indicators (Tables 1), the participants in the research have highly developed MT, which is in line with results of previous studies [8]. This well-known fact that athletes differ from the general population in terms of their more developed MT is illustrated by all 3 questionnaires. Due to the specificity of the population, the obtained scores are quite homogeneous and shifted towards the maximum values. This limited range of manifestations of various MT scores had an impact on the metric characteristics. Since this is a study with a clear applicative character, the results were not subjected to the procedure of removal of the outliers, which also had the impact on the metric characteristics. Never the less, almost all descriptive parameters speak about good metric characteristic of all MT scores. The exceptions are deviations from normal distribution in Constancy, Determination, and MTI. Considering mentioned characteristics of the subject's population and an absence of outlier detection procedure, this kind of deviation is expected, but more importantly easily repairable, and that is why it is acceptable. This is clearly illustrated with Q-Q plots (Figure 1). Also, since the MTI instrument is mainly intended for the general population, it showed quite good characteristics in the sports population as well. Taking everything into account, the obtained results speak in favour of the discriminativeness of the online versions of all three measuring instruments.

According to reliability parameters (Table 2) MTI shoved the best properties, PPI-A was also very good, and SMTQ can be described as acceptable. Never the less, if taken into account the relationship between the size of Cronbach's alpha scores and the number of scales that make up one score, it can be clearly observed that all three instruments behave in a good way according to this parameter. Also, the obtained reliability of the online version of the questionnaire is quite similar to that obtained in the validation studies of the paper versions [18, 19, 9, 20, 21, 22].

The results of correlation analyses (Table 3) are also in line with the results of previous studies [6]. Considering the direction, intensity, and number of obtained correlations it can be easily claimed that the construct validity of online versions of all three instruments in a population of basketball players is confirmed.

In the end, this study for the subject of analysis had the psychometric properties of online versions of already validated instruments, which are in widely used in sports and research practice. Taking everything into account, the online tests showed at least the same psychometric characteristics as the paper versions [6, 9, 18, 22, 19, 21, 20].

Like any research, this one has its limitations. In addition to the already explained problems with the lack of live presence of the examiner, which was mainly justified considering the goals of the study, the biggest limitation concerns the sample. In order to reach a final conclusion on the subject that was researched, it is necessary to repeat the research on a larger and more diversified sample, both according to sport and according to other demographic characteristics, gender above all.

Finally, it should be emphasized that the researched use of online versions of questionnaires concerned primarily this method when collecting data for the purpose of scientific research, because nothing can and should not replace real face-to-face or even group psychological testing. Also, the change of media and the setting of questionnaire application does not mean that the psychologist's role in this process automatically changes, but on the contrary, psychologist's role must remain unchanged and irreplaceable in the process of ensuring ethical standards of research, processing and interpretation of data so that the research method of applying psychological questionnaires will be valid. In the end, if additional studies show similar results as this one, it would still be recommended that this method be used only in conditions where traditional psychometric testing is not possible.

4. CONCLUSION

Having in mind that good metric characteristics, discriminativeness, reliability and construct validity of online versions of SMTQ, PPI-A, and MTI questionnaires for assessing MT was clearly demonstrated by the obtained results, it can be concluded that this method of measuring instruments shove good psychometric characteristics. Adding to this the efficiency of data collection with the help of online platforms, striving towards a valid implementation of online solutions in psychometric practiced is quite justified. This study represents one small step in that direction. Therefore, it can be concluded that this study met its aims, although further research with larger and more diverse samples is still necessary before online versions of psychological questionnaires become part of standard research practice. Also, further improvement of data gathering process with more usage of online IT solutions, which will improve validity of this method is needed before it become common research practice.

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INFORMATION TECHNOLOGY IN SPORTS SESSION

PSYCHOMETRIC PROPERTIES OF ONLINE VERSIONS OF EMPATHY AND DARK TRIAD PERSONALITY TRAITS QUESTIONNAIRES IN BASKETBALL PLAYERS

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Abstract:

The goal of this study was to examine the psychometric properties of using the online version of self-report questionnaires for assessing empathy and dark triad personality traits to gather and analyse the data in scientific research. The assumption was made that, with the right written explanation and introduction to the questionnaire, the participants will fill out the online forms in the way that will revile good psychometric properties of the results.

Sample for the study was composed out of 79 male athletes that actively played basketball in a 22/23 season. They filed an online version of the Sports Interpersonal Reactivity Index (IRI), and The Dark Triad Dirty Dozen (DTDD).

Results of descriptive analyses reviled good and acceptable metric characteristics and discriminativeness of both questionnaires. Good reliability was confirmed with obtained Cronbach's alpha coefficient scores for DTDD but reliability of IRI scores was questionable. Obtained correlations among scales and subscales speak in favour of construct validity of online versions of questionnaires.

It was concluded that further research of this topic is necessary but also justified.

Keywords:

Online platforms, Online questionnaires, IRI, DTDD.

INTRODUCTION

Basketball is a collective sport, which implies that, in order to participate and achieve a positive outcome, an individual has to have a social interaction with other individuals in his environment. The way the individual perceives and interacts with its social environment is determined by one's personality traits. Two such traits, that were studied over last decades are empathy and dark triad. Many authors refer to empathy is a key component of social interactions by promoting prosocial behaviours while inhibiting aggressive behaviours toward others. [1], [2], [3]. Empathy is broadly defined as the capacity to imagine, experience, and understand what the other person is feeling, [3] or it is described as the ability to experience and understand what others feel without confusion between oneself and others. [4] [3] Decety and Lamm [4] noted that empathic concern is defined as an emotional reaction characterized by such feelings as compassion, tenderness, softheartedness, and sympathy.

Empathy is considered a multidimensional concept that contains the cognitive, perspective-taking capabilities or tendencies of the individual, and the affective or emotional reactivity of such individuals and the influences that these components may have on behaviour. [5] Decety and Jackson [6] [3] refer to empathy as an a phenomenon that requires both the ability to share the emotional experience of the other person (affective component) and an understanding of the other person's experience (cognitive component) as vell as natural ability to understand the emotions and feelings of others, whether one actually witnessed his or her situation, perceived it from a photograph, read about it in fiction book, or merely imagined it. On the other hand, the dark triad is a term used to describe a constellation of three socially undesirable personality traits: narcissism, psychopathy, and Machiavellianism. [7] [8] Narcissism is characterized by a grandiose sense of self, entitlement, dominance, and superiority; Machiavellianism by manipulativeness, callous affect, strategic planning, and superior impulse regulation; and psychopathy by thrill-seeking, lack of empathy and remorse, superficial charm, low anxiety proneness, and a lack of longterm goals. [9] [10] [11] Specifically, the Dark Triad as a whole can be thought of as a short-term, agentic, exploitive social strategy that may have evolved to enable exploitation when conspecifics are likely to avoid or punish defectors. [12] [8] Jonason and Webster further developed the test for psychometric properties that contains 12-item version of the Dark Triad called the Dirty Dozen (DTDD). [8] The Dirty Dozen represents a brief measure of each of the three traits composed of 4 items for each dimension was designed to maximize the intercorrelations between the traits and, thus, doing so is an essential task to understand the validity of each dark triad subscale. [13] Jonason, Kaufman, Webster and Geher [14] claim that scores on the psychopathy subscale of the DTDD to be correlated with emotional instability and disagreeableness through high rates of volatility and low rates of compassion. Although some researchers like Haar and de Jong [13] argue that dark triad personalities might have an edge over the competition and be beneficial in highly competitive environments and jobs like CEOs and managerial jobs it is jet to be seen what kind of influence DTDD have in sports. Studies on personal traits are usually conducted by a self-valuation questionnaire that would place the results on a scale measuring the construct [15]. The scales usually used are Likert 5- or 7-point scales, where 1 represents a false claim 100% and the opposite and 100% true is represented by biggest number (5 or 7), with the numbers in between representing the claims slowly graduating from one statement to another. Often the purpose of the research is to understand the opinions/perceptions of participants related with single 'latent' variable phenomenon of interest. This 'latent' variable is expressed by several 'manifested' items in the questionnaire [16]. For example, by agreeing or disagreeing with the statements like "I laugh a lot" regarding humour, and "I am always committed and involved" regarding sense of purpose, the person is actually answering the question of happiness and subjective well-being. [17]

COVID-19 pandemic, changed how we interact and do research. Before the pandemic questionnaires where, usually written on paper [18], but the person doing the research had an advantage, being present in person to interpret and conduct the process. Online environment and transdisciplinary attitude were needed to develop scientific research, given the complex societal challenges we are facing [19]. Collecting samples via online platforms, which was practically the only safe way to conduct large-scale research during the last couple of years, become very practical and effective. Biggest strengths of the online survey are: global reach, business-to-business and business-to-consumer appeal, flexibility, speed and timeliness, technological innovations, convenience, ease of data entry and analysis, question diversity, low administration cost, ease of follow up, controlled sampling, large sample easy to obtain, control of answer order, required completion of answers, go to capabilities, knowledge of respondent vs. nonrespondent characteristics, while the major potential weaknesses are: perception as junk mail, skewed attributes of internet population: upscale, male, etc., questions about sample selection (representativeness) and implementation, respondent lack of online experience/expertise, technological variations, unclear answering instructions, impersonal, privacy and security issues, low response rate. [20]

On the other hand, when it comes to surveys aiming to examine psychological constructs, psychological assessment without a psychologist present, who would administrate the tests and interpret the obtained results, is very problematic. In order for psychological assessment to be valid presence of psychologist as a person who monitors the entire process of the examination is obligatory. With online testing, the biggest problem is the absence of a psychologist during filling out the questionnaire. However, in the process of data collection, the psychologist's physical presence can be partially replaced by his online presence through applications such as Google Meet, Microsoft Teams, and the like. After this step, the psychologist, as a person who ensures the validity and ethics of data storage, processing and interpretation, is equally present when questionnaires are filled out in classic or online form. Nevertheless, question that arises is how valid such method of running research, regarding the fact that most of the questionnaires were intended to be filled in with the physical presence of the examiner.

The aim of this study is to examine the psychometric properties of using the online version of self-report instruments for assessing empathy and dark triad personality traits to gather and analyse the data in research practice. The assumption was made that the results will have good psychometric properties which will imply that this topic deserves further examination and validation.

2. METHOD

2.1. PARTICIPANTS

Sample used for this research was a total of 79 male athletes that played basketball in the 2022/2023 season. The participants were divided in two categories, Serbian speaking and non-Serbian speaking. Non-Serbian speaking participants where filling an English version of the questionnaire, and the participants that speak Serbian language were filling a Serbian language translation. 54 participants filled Serbian language form (age = 21.6 \pm 4.9) playing for 9 different clubs, in three different divisions (14 participants was playing in the 1st division during the 22/23 season, 14 of them played in 2nd division, and 28 of them played in the 3rd division). 14 out of 54 participants still played in youth competitions and had a junior status while the other 40 had only a senior status. The sports experience (number of years playing the sport) of the participants was on average of 11.7 \pm 5.5 years. 21 of them we define as an elite athlete (had national team experience during the career) while 33 of them never had any national team experience. Regarding the playing position in the team, 14 of them were playing as a point guard (1), 12 of them were shooting guards (2), 11 small forwards (3), 11 power forwards (4), and 5 of them were playing centre (5) position. English form was filled by 25 participants (age 18.6 ± 5.0) playing for 3 different clubs, from which 11 had a cadet status, 6 of them were juniors and 8 of them played senior basketball with an average experience in sport of 9.3 \pm 4.8. 3 of them were 1st division players, 9 played in 2nd division while 13 played 3rd division in the course of the 22/23 season. 8 had a national team experience during their career and 17 of them had none. Regarding the playing position in the team, 4 of them played as a point guard (1), 7 of them as a shooting guard (2), 4 were small forwards (3), 6 power forwards (4), and 4 of them were playing center (5) position.

2.2. MEASUREMENTS AND PROCEDURES

Google Forms was a tool of choice to collect and analyse the data for this study. It allowed us to compose a questionnaire, collect answers from participants, present data in spreadsheet format using Google Sheets, which makes tracking and analysing the data easier for everyone involved. [21] Participants, during this study, were filling the questionnaire in privacy, comfort and at the time when they felt like it, usually using their mobile phones, just following the link sent to them by their coach. This is not a standard environment for a study like this witch raises the question of validity of the results. Google Forms is a web-based survey tool. It offers no limits regarding the number of surveys conducted and number of respondents. Survey answers and data are automatically collected in Google Spreadsheets. It offers an option to embed any survey into emails or websites. Has a lots of theme options and options to add a custom logo, photo or video. Collaboration is the only option comes with only limitation in data privacy. [22] It has a great potential for any type of similar studies, thus the attempt to validate the results. Web-based surveying offers researchers plenty advantages in comparison to more conventional survey modes, these findings suggest that non-market valuation practitioners should consider the use of this survey administration mode in the future. [23] For our study we chose Google Forms as it provides various options to capture the data from the multiple answers and can have multiple choice options, check boxes, scale, grid, text, and etc. [22]

Since aim of the study was to investigate the psychometric properties of the online version of psychological questionnaires, the idea was that additional means that would ensure greater validity such as video instructions, online presence through meeting platforms and chat with the examiner were not used. In this way, in comparison with the results of earlier validation studies, it was possible to analyse the effect that the change of media and environment has on the psychometric properties of the results.

2.3. STATISTICAL ANALYSES

The online questioner was set in the way that prevents existence of missing values and multiple answers, thus enabling the analysis to be carried out immediately after data collection. The data were, at first, subjected to descriptive statistical analysis and minimum, maximum, mean, standard error of mean, standard deviation, coefficient of variation, skewness as well as kurtosis was calculated. To determine the normality of the data distribution, we used Kolmogorov-Smirnov nonparametric test. To determine the reliability of the instruments reliability analysis was used and Cronbach's alpha coefficient as Cronbach's alpha coefficient based on standardized Items was calculated. Spearman's nonparametric correlation test was used to construct and convergent validity. In order to achieve discriminant validity assessments descriptive statistics, skewness and kurtosis as well as nonparametric Kolmogorov-Smirnov test were used.

Statistical significance was defined at the level of 95% probability, for the value of p < 0.05 and at the level of 99% probability, for the value of p < 0.01. All statistical analyses were performed using SPSS 20 (IBM Corp., Armonk, N.Y., USA) and Jamovi (version 1.2.27.0).

The analysis also shows that the sample was quite heterogeneous on DTDD variables and personal distress and more homogenous on rest of the variables. Descriptive statistics and the Kolmogorov-Smirnov nonparametric test showed there are no significant deviations from the normal distribution except Machiavellianism and narcissism.

The analysis of the observed deviations of the distributions in Machiavellianism and psychopathy was done with the Q-Q plots (Figure 1). The presence of outliers at higher scores as well as accumulation in minimal values can be observed in both distributions. Considering the applied goals of this work, elimination of outliers want be performed and further analyses will be done on the original data and scores.

Reliability analysis (Table 2) for both IRI and DTDD was performed at the level of individual answers of all respondents and items for total scores and subscales. Obtained Cronbach's alpha coefficient scores prove to be excellent and very good for all DTDD variables, acceptable for total IRI score and personal distress, questionable for fantasy, perspective taking and empathic concern.

3. RESULTS

Descriptive statistical analysis was performed for the total scores as well as for the scores on subscales of the IRI and DTDD for the whole sample (Table 1). Standard error of mean ranging from 2.47% (empathic concern) to 6.12% (psychopathy) of mean scores enables accurate and narrow estimation of the population mean.

Table 1 - Descriptive statistics for the IRI, and DTDD scores.									
	Minimum	Maximum	Mean	SEM	Std. Deviation	COV	Skewness	Kurtosis	Kolmogorov- Smirnov Z
Fantasy	1.00	3.86	2.12	0.07	0.62	0.29	0.50	0.01	1.02
perspective taking	1.29	4.00	2.37	0.07	0.59	0.25	0.08	-0.23	0.91
empathic concern	1.29	3.43	2.29	0.06	0.50	0.22	0.02	-0.64	0.90
personal distress	0.00	2.71	1.19	0.07	0.60	0.51	-0.27	-0.52	1.09
IRI	1.18	2.75	1.99	0.04	0.36	0.18	0.04	-0.06	0.72
Machiavellianism	1.00	7.00	2.25	0.17	1.50	0.67	1.66	2.45	1.78*
Psychopathy	1.00	7.00	2.50	0.15	1.35	0.54	1.04	0.65	1.38*
Narcissism	1.00	7.00	3.49	0.18	1.57	0.45	0.14	-1.04	0.93
DT	1.00	6.50	2.75	0.13	1.14	0.42	0.74	0.26	0.92

* Significant at the 0.05 level



Figure 1 – Q-Q plots for Machiavellianism and psychopathy scores.

	Cronbach's a	Cronbach's α Based on Standardised Items	N of Items
Fantasy	0.55	0.54	7
perspective taking	0.6	0.61	7
empathic concern	0.59	0.59	7
personal distress	0.69	0.7	7
IRI	0.68	0.67	28
Machiavellianism	0.9	0.91	4
Psychopathy	0.81	0.81	4
Narcissism	0.82	0.82	4
DT	0.87	0.87	12

Table 2 - Reliability	v statistics f	for the	SMTO	$DDI_{-}\Delta$	and MTI	scores
Table 2 - Renability	y statistics i	for the	SMTQ,	PPI-A	and MITI	scores.

Table 3 - Correlation analyses for the IRI and DTDD scores.

	perspective taking	empathic concern	personal distress	IRI	Machiavelli- anism	Psychopathy	narcissism	DT	MTI
Fantasy	.324**	.325**	.245*	.756**	.057	133	.250*	.064	.524**
perspective taking		.435**	139	.636**	049	335**	.054	096	.433**
empathic concern			097	.656**	232*	518**	.060	218	.422**
personal distress				.3703**	.357**	.161	.171	.217	0.159
IRI					.050	352**	.191	032	.795**
Machiavellianism						.572**	.315**	.734**	.709**
Psychopathy							.349**	.775**	.551**
Narcissism								.763**	.683**

** Correlation is significant at the 0.01 level (2-tailed), * Correlation is significant at the 0.05 level (2-tailed).

Spearman's nonparametric correlation analysis was performed for IRI and DTDD for the total scores as well as for the scores on subscales on the whole sample (Table 3). Among scales and subscales, low to high significant positive and negative correlations were obtained. Correlation of empathic concern and DT was on the edge of statistical significance (p=0.056). Having in mind goals of this paper significant negative low correlations of psychopathy and IRI scores attract the most attention.

4. DISCUSSION

This study aimed to examine the psychometric properties of online version of the IRI and DTDD in the population of basketball players. Majority of the findings confirmed good psychometric characteristics of online versions of questioners in sport population, making this way of gathering data in scientific research worthy of further research.

According to descriptive indicators (Tables 1), the participants in the research have not very well developed empathy and also weakly present dark triad personality traits. When discussing the metric characteristics it should be kept in mind that both questioners are intended for general population. Never the less, they demonstrate solid metric characteristics in selected sport population. Also, because of applicative character of this study, the results were not subjected to the procedure of removal of the outliers. That is why observed deviation from normal distribution in Machiavellianism and psychopathy can be characterised as acceptable, which is illustrated with Q-Q plots (Figure 1). Also, in previous validation studies [24] some violation of normality of distribution of the DTDD scores was also obtained, which speaks in favour of acceptability of obtained results. Taking everything into account, the obtained results speak in favour of the discriminativeness of the online versions of both measuring instruments.

According to reliability parameters (Table 2) DTDD shoved excellent properties. This finding is in line with finding of previous validation studies [24], and more over online version shoved greater reliability than paper version in some earlier studies [25]. On the other hand, IRI was quite questionable when it comes to reliability. While perspective taking, personal distress and IRI total score can be described as acceptable according to the Cronbach's alpha coefficient scores, this is not the case with fantasy and empathetic concern. However, having in mind sample, it could be assumed that this deviation is the cause of the sample size and its selected character rather than the online way of filing the questionnaire with already proven reliability [5, 26, 27].

Results of correlation analyses (Table 3) are also in line with results of previous studies [28, 5, 26, 25, 27]. Having in mind direction, intensity, and number of obtained correlations it can be easily claimed that construct validity of online versions of all three instruments in population of basketball players is confirmed.

It is necessary to emphasize the limitations of this research. First, it concerns the sample, primarily its size and unrepresentativeness. Further research is needed with a larger and more diversified sample, both according to sports disciplines and other demographic characteristics. Second, given the exploratory nature of this study, numerous limitations are related to the validity of psychological assessment without the presence of an examiner. The next researches should gradually introduce one technological solution at a time, which would simulate the presence of the examiner to a greater degree, which should lead to a greater degree of validity of this method of research.

In the end, regardless of the possible results of future validation studies, the author's opinion is that we are still far from possibility of valid replacing the live presence of the examiner in the process of psychological assessment. researched methodology, although tempting and effective, should actually be an alternative solution in moments when direct face-to-face examination is not possible. Also, this research does not advocate changing the role of psychologists in the process of psychological assessment, especially when it comes to monitoring, ensuring ethics, storing, processing and interpreting the results.

5. CONCLUSION

Having in mind that good metric characteristics, discriminativeness, reliability and construct validity of online versions of IRI and DTDD questioners was clearly demonstrated by the obtained results, it can be concluded that this way of using of measuring instruments shoved good and acceptable psychometric characteristics. Adding to this the efficiency of data collection with the help of online platforms, further research and development of implementation of informational technology in psychological assessment is quite justified. Therefore, it can be concluded that this study met its aims, although further research with larger and more diverse samples is still necessary before online versions of psychological questionnaires become part of research practice.

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TRACKING OF THE RELEVANT FITNESS PARAMETERS IN YOUNG BASKETBALL PLAYERS

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Abstract:

The application of modern technologies has become a critical issue in modern sports, which can be very helpful in improving the performances of athletes. The monitoring of many indicators has been realized by using flexible, wearable sensors. In the current study, we aimed to analyze the performance of young basketball players on four consecutive trial matches using the Kinexon perform mobile system which is one of the global market leaders in the field of real-time recording and processing of sports performance data.

Twelve male members of the Hungarian national U18 basketball team were participants in this study. Measures of the study included internal and external load indicators. Accurate measurements about the total load from the data summarized in Kinexon were decisive for the model that the team had after the last game played. On the first day after the tournament, the team had a break with enough time to sleep and an appropriate dietary regime. On the second day after that, recovery training was done. The following day, the team was able to return to basketball training without great intensity and with a drastically reduced number of jumps as well as accelerations and decelerations. Based on the results of this study, we can conclude that Kinexon perform mobile system is a very useful tool in performance profiling, loads, and injury management.

Keywords:

Fitness indicators, Basketball Players, Team Sports.

INTRODUCTION

Application of modern technologies is well documented in two major fields of physical culture i.e., sports, and physical education [1], [2]. However, using systematic, scientific monitoring systems to monitor performance indicators has become a critical issue in modern sports, which can be very helpful in improving the performances of athletes. The ever-increasing demands in modern sports emphasize the need for adequate training load management i.e., the prescription, monitoring, and adjustment of workload [3]. An inappropriate prescription of training load and recovery, especially in youth sports, can lead to injury, overtraining, or poor performance. Hence, it is of utmost importance to closely observe the external (overall amount of the physical work) and internal (psychophysiological stress derived from the external load) aspects of training load to learn the athlete's level of fatigue, objectively assess recovery time, and detect a decline in performance early. The ultimate goal is related to individualization of the training load and recovery to optimize performance and reduce the risk of injury [4] - [6].

Some of the best applicable systems are microelectromechanical systems (MEMS) and they constantly improved over the last two decades. Presently they are included in a range of consumer products commonly known as "wearables" and offer various data of sensor systems [7]. Understandably, tracking in team sports, in comparison to individual sports, is far more complex since it tends to quantify two parties who try to outperform one another and win a competitive game [8]. This is more emphasized in modern, highly competitive sports, where the quick actions and reactions of every athlete change in a blink of an eye.

The monitoring of many indicators has been realized by using flexible, wearable sensors. According to a recent systematic review of wearable sensors for sports, these can be categorized as follows: (1) kinematical indicators, including posture, motion, force, and acceleration; (2) physiological indicators, including vital signs (e.g., breath, pulse, ECG, heart beating, blood pressure, temperature, SpO2, etc.) and metabolites during and after exercises (e.g., glucose, pH, electrolytes, lactic acid, etc.) [5] .In the current study we aimed to analyse the performance of young basketball players on four consecutive trial matches using Kinexon perform mobile system [9].

2. MATERIAL AND METHOD

Kinexon is one of the global market leaders in the field of real-time recording and processing of sports performance data. We used some of the internal and external load features of this reliable and accurate [10], [11] tracking system for real-time feedback on athletes' performance.

Twelve male members of the Hungarian national U18 basketball team were participants in this study. Sample characteristics are presented in Table 1.

As shown in Table 1, the sample is the most homogenous in BMI (SD=1.69), with an average value of 22.49. The mean value for BMI indicates that these young athletes, as expected, fall into the category of healthy weight for their age and sex, with BMI cut-off points 18.5-24.99 [12].

Internal and external load indicators used in this study were:

- Maximum and average heart rate (Hr max, Hr av);
- Distance travelled per minute (Tot dist/min) and Trimp (a measure of the amount of internal effort)
- Number of accelerations (Acc) and decelerations (Decc) and the total player load (Acc Acc);
- Maximum speed of accelerations and decelerations (Max acc, Max dec) and the average speed (Speed av.);
- Force broken down by body weight (Power/ mass) and the total load on the player in minutes (Acc load/min.);
- The mechanical load broken down into a unit of time (Mech Int) and the number of jumps (Jumps).

3. RESULTS WITH DISCUSSION

Sport performance indicators of the U18 national basketball team of Hungary were measured during a four-day tournament (one game per day). Figure 1 shows the maximum and average heart rate, the number of accelerations and decelerations, and the total player load during the matches. The biggest cardiovascular and external load was in the match on the 28th of December. The lower load on the match held on the 27th of December can be explained by the number of players (the team played 10 players in this friendly match).

Variable	Minimum	Maximum	Range	Mean	SD			
Body height	175.00	206.00	31.00	196.00	9.13			
Body weight	70.00	104.00	34.00	86.58	10.70			
BMI	18.9	25.2	6.3	22.49	1.69			

Table 1 - A sample characteristics.



Figure 1 – Maximum, average heart rate, number of accelerations, decelerations and the total player load.



Figure 2 – Mechanical load, number of sprints, jumps and maximal speed.



Figure 3 – Maximum speed of accelerations and decelerations, force broken down by body weight, the total load on the player in minutes, and the average speed.



Figure 4 - Distance travelled per minute and Trimp (a measure of the amount of internal effort).

Figure 2 shows both the number of sprints and the speed, where the 28th of December match proved to be the most stressful one. The mechanical load broken down into a unit of time and the number of jumps are also shown in the figure.

The maximum speed of acceleration and deceleration, and the average speed were also the highest on the 28th of December (Figure 3). The graph also shows the force broken down by body weight and the total load on the player in minutes.

Distance travelled per minute and Trimp (a measure of the amount of internal effort) are shown in Figure 4. It is noticeable that the December 28 match was the biggest strain on the cardiovascular system.

In a tournament system of competition that is played according to this system where 4 games are played every day, the load that is not monitored in this way can only be "assumed" or processed in some less relevant way. As it is about national selection and controlled load conditions in the period after the tournament, it can be clearly concluded that in the first following days, all available means of recovery should be primarily used, followed by recovery training as well as activation for the next microcycle. In this case, the awareness of the age category with the data that we obtained about the total load from the data summarized in Kinexon was decisive for the model that the team had after the last game played. On the first day after the tournament, the team had a break with enough time to sleep and an appropriate dietary regime. On the second day after that, recovery training was done, which included all means of recovery in the gym, such as breathing exercises, massage, dynamic stretching, activation exercises on the floor, a set of exercises without additional load (body weight), and exercises with weights for the whole body without a large

workload. The next day, the team was able to return to basketball training without great intensity and with a drastically reduced number of jumps as well as accelerations and decelerations that were available to us from the results (Kinexon).

4. CONCLUSION

In the current study we aimed to analyze the performance of young basketball players on four consecutive trial matches where we used some of the internal and external load features Kinexon tracking system for real-time feedback on athlete performance. With such a monitoring system where you have relevant data with awareness of the psychological pressure for each match as well as the cumulative effects of fatigue, we were able to make adequate decisions about the workload of the players for the next match as well as the means of recovery individually for each player. Of course, the processed data in real-time and then the cumulative data after the competition determine the programming of the next period. Based on the results of this study, we can conclude that Kinexon perform mobile system is a very useful tool in performance profiling, loads, and injury management.

5. ACKNOWLEDGEMENTS

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INFORMATION TECHNOLOGY IN TEACHING FOREIGN LANGUAGES SESSION

USING MOODLE IN EFL TEACHING IN ITALY: THE CASE OF EVERYWHERE

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Abstract:

Nowadays, higher education institutions are faced with the complex challenge of serving increased enrollment levels with tighter budgets. This has prompted universities around the world to explore new approaches, including the use of Learning Management Systems (LMS) - such as Moodle - for delivering courses to help extend teaching and learning beyond the classroom. The implementation of these systems was also spearheaded by the forced adoption of online tools during the Covid-19 pandemic.

This paper investigates UNINT (Università degli Studi Internazionali di Roma) educator and learner experiences in using a modified version of Moodle - called Everywhere - as an online learning management system, which was created to facilitate learning in the context of English as a foreign language (EFL). In particular, it examines issues about adopting Moodle as an online learning management system and implementing blended learning in EFL/ESP education.

The incorporation of Moodle into Everywhere learning platform has led to the development of an interactive platform for both students and teachers. The authors discuss their own course page on Everywhere, which is seen as a boon for the development of an interactive learning platform, but it is highlighted the course might become even more blended with further implementation of the plethora of resources and activities available to course developers.

Keywords:

Moodle, Italian higher education, English as a foreign language (EFL), Blended learning, English for specific purposes (ESP).

INTRODUCTION

The paradigm of education has changed around the globe due to the combination of the recent development of smart technology with their forced adoption during the Covid-19 pandemic. Various web-based course management systems or instructional approaches have been integrated into classroom learning and teaching in order to inspire the study experience of a digital-native, young generation.

Moodle is a web-based *learning management system* (LMS) with pedagogical approaches based on constructivism, which emphasizes the roles of shared learning communities, learner-centeredness, and social interaction in the learning context.

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e-mail: fabrizio.gallai@unint.eu It allows educators to create and manage online courses and has become an essential tool for many educational institutions as it provides a flexible and customizable platform for delivering course content and facilitating communication between students and teachers [1].

In particular, this LMS is aimed to promote enhanced learning in higher education, and provides great opportunities for organizing the educational process and is welltested in practice [2], and can be used to improve graduate and post-graduate students' learning. Susana et al. [3] state that Moodle extensively enables this type of learning because of these three characteristics: a. interaction, enhancing student-student discussions; b. usability (as it has a variety of useful options for students such as easy installation, customization of the options, easiness of navigation; etc.); and c. social presence, i.e., promoting a sense of community in online courses. However, a systematic review on trends in using Moodle for teaching and learning found that Moodle is mainly used within University STEM disciplines and effectively improves student performance, satisfaction, and engagement [4]. Scholars also found that Moodle is increasingly being used as a platform for adaptive and collaborative learning and used to improve online assessments.

In conclusion, the use of Moodle in higher education is developing rapidly to address academic integrity, ethics, and security issues to enhance speed and navigation, and incorporate artificial intelligence. Technological factors, social factors, human factors, and reinforcement factors affect the adoption and use of the Moodle platform [5]. To date, the success of this virtual platform among the university community has been mainly based on offering a permanent repository of contents, units, assignments, and essays that can be shared at any time [6]. However, it is still unclear to what extent the use of Moodle allows students and teachers to build collaborative learning, in what is the ultimate goal of educational research.

2. USE OF MOODLE FOR TEACHING ENGLISH AS A FOREIGN LANGUAGE (EFL)

Moodle naturally lends itself to the teaching of languages, both with its collaborative activities such as Forum, Chat or Wiki and, for those with the time and aptitude for DIY, suggestions include a number of plugins such as Hot Pot quizzes (http://hotpot.uvic.ca), audio and video [7], and, more recently HP5 (HTML5 Package, https://h5p.com). The latter can be accessed through the content bank on Moodle (provided the site administrator enables the HP5 library), and this can be used for seamless creation of responsive content interactive activities, which, at the moment, include over 50 content types. This plugin makes it much easier for non-expert users to create modern-looking interactive content. Many of the HP5 resources can also be repurposed in four of the standard Moodle question types that allow educators to develop more interactive quiz/ test questions. Not surprisingly, most HP5 can easily be incorporated into the foreign-language classroom to enhance learning and foster a student-centered learning environment.

2.1. MOODLE AND FLIPPED LEARNING

Flipped learning has been introduced as an effective instructional method which can supplement conventional teacher-centered instruction and help to promote learner-centered learning in the classroom. Jeong [8] argues that Moodle can be used to enrich flipped learning for EFL education. Along with the use of Moodle as the learning management system, adopting flipped learning as an effective instructional strategy can exploit the full potential of the constructivist paradigm.

2.2. USING MOODLE FOR BLENDED LEARNING

Blended learning is possible in modern era using information communication technology (ICT) based learning management tools. It has proven to be a successful approach to education that combines online educational materials and opportunities for interaction online with traditional place-based classroom methods [9], [10] paper describes why blended learning is so significant in higher education. In particular, scholars compare Moodle with other open-source learning management systems such as ATutor, Eliademy and Forma LMS, and a case study of Moodle that demonstrate how it is an effective in blended learning in higher education.

Moodle can specifically be used for blended learning in teaching English as a foreign language (EFL) and English for special purposes (ESP). When teaching EFL and ESP using Moodle for Blended Learning, teachers can pre-teach given lexical items (using Flashcards and other similar activities, as we shall see below in 3.2), present content that introduces relevant and authentic situations (through other activities such as Wiki, Chat, Forum, etc.) and engage pupils so that they participate actively.
3. CASE STUDY: EVERYWHERE LEARNING PLATFORM AT UNINT

As a direct consequence of the COVID-19 pandemic, UNINT University (based in Rome, Italy) was fast to adopt new technologies to aid both educators and students. Since online teaching in Italy was widely adopted well into the 2021-22 academic year, universities were forced to find suitable solutions for online classrooms in a very short time. As a result of these rapid transformations, UNINT built and implemented its own platform, *Everywhere* (https://everywhere.unint.eu), based on a modified version of Moodle (currently Version 3.11.3, Build 20210913) with the integration of Zoom for streaming and video collaboration. The theme Herald Boost (v6.0, https://elearning.3rdwavemedia.com/themes/ moodle-theme-herald-boost/) was adopted for the specific needs of the university.

As we can see in Figure 1, the platform was developed with both learning and collaboration in mind which allows both learners and educators to access learning content wherever they want in full security, attend graduations sessions, and follow live lessons:



Figure 1 - UNINT Everywhere platform.

The platform is now an integral part of the course structure at the university and many students continue to follow courses online. In the next sections, the Everywhere platform will be introduced (cf. 3.1), and a case study of its implementation for an MA-level ESP course described (cf. 3.2). This section will end with final remarks on blended learning at UNINT (cf. 3.3).

3.1. THE PLATFORM

Once authenticated and logged in, users can access their courses and find information about both the technologies adopted on the platform and information about the university and their faculty, which are all in one place. While much of the contents are available only to university staff and registered students, there are various forms of temporary access to allow users outside the organization to access certain content. When developing their online platform, IT experts at the UNINT chose Moodle for the obvious reasons of it being an open-sourced, and thus easily adaptable for the specific needs of this university, and it is widely used at other learning institutions throughout Italy and the rest of the world. They main objective was to create a single space where both students and teachers could continue to interact during the pandemic (when F2F contact was impossible) and later for hybrid learning environments. In fact, at the time of writing (May 2023), UNINT students can still follow all their courses both online and in person. Another important consideration was ease of use for the teaching staff, especially at the time of the pandemic when educators were faced with so many different online tools at the same time, with little time to study them. As soon as the platform was activated a number of online seminars were organized to illustrate its main functions.

Integration with Zoom is a key feature of Everywhere. Initially, the open-source virtual classroom Big Blue Button (https://bigbluebutton.org) was used but according to IT staff at the UNINT there were too many problems with connection, number limits and quality to make it a viable alternative for the university. Since the introduction of Zoom on the platform such problems are much less common and the integration of the Zoom meeting plugin on Moodle is completely seamless. Another factor that led to the choice of this software over the previous one is the possibility of enabling language interpretation, a feature that is widely adopted at the UNINT for interpreter training through the creation of virtual interpreting booths. While obviously the use of Zoom incurs payment of an Education license fee, the many positive aspects of this application clearly outweigh the negative ones. Currently, educators can host meetings with up to 300 participants and have access to unlimited editable whiteboards. Furthermore, students can create meetings with their peers with a 40-minute time limit.

On their dashboard both learners and educators can easily access their courses and can find links to other university services and events, such as graduations, conferences and seminars. From there access to course content is the matter of a simple click of the mouse. We shall see in the next session how this is done in an actual course.

3.2. THE COURSE AND ITS IMPLEMENTATION ON EVERYWHERE

We will now describe in detail the adoption and implementation of Everywhere for the English Language and Linguistics course, which is obligatory for all firstyear MA-level English language students (in two separate degree courses – one, LM94, for Interpreting and Translation Studies and the other, LM37, for future language teachers). The main theoretical focus of the course is applied (Critical) Discourse Analysis for interpreters and translators with a focus on media, political and legal discourses [12], [13]. For the sake of brevity, in this description we will be focusing only on the latter.

Let us begin by looking at the set-up of the course

page in Figures 2 and 3. The students click on the course name on their personal dashboards and find sections for Course updates (a Forum activity) from three course lecturers, more specific course information (Label), Zoom lesson links (in the Lessons section). Scrolling further down the course page there are other sections: Teaching Materials (which include folders, web-page links, activity chooser for quiz sign-up and other activities), Exams (not shown), and Online Activities (Figure 3). It should be noted that the pre-defined names of the individual sections are in Italian and it is up to the course teacher(s) to change them. In the current example, for obvious reasons, we have decided to change to names to English in so far as possible.

We will now briefly discuss a few of the activities located in the Online Activities section of the course page (Figure 3). This section includes a collaborative Glossary about institutional and legal discourse as well as a number of HP5 activities for individual and group practice. Due to the peculiarities of legal English students are encouraged to collaborate on the creation of the course glossary. Students can easily add glossary entries following the example given in the directions, and collaboration is enhanced through the use of the Comment feature which has been enabled.

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Figure 2 - Everywhere course page for Lingua e linguistica inglese.

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	anning 2tr. The Grown-Court Part 8
	annag 3: Differences between over and otherate cases

Figure 3 - Online Activities.



Figure 4 - HP5 Flashcards activity for legal English.

As far as the HP5 activities are concerned in the Online Activities section, the authors have made ample use of the Flashcards, Complex Fill in the Blanks¹ activity, and Drag and Drop activities, which appeared particularly suitable for the introduction of complex legal and institutional lexical structures and themes. Other activities such as Question Set will be incorporated later for revision purposes.

In Figure 4 we can see an example of a Flashcards activity. The focus is legal professions and students are encouraged to review complex legal lexical structures in a straightforward manner. We should recall that since HP5 activities are mobile friendly, so learners can review their vocabulary flashcards on their mobile devices as well.

In the support materials on the HP5 support page (https:// h5p.org/tutorial-advanced-fill-in-the-blanks), this is known as *Advance Fill in the Blanks*; however, in the Content Bank - where the HP5 activities can be created and edited - it is known as *Complex Fill in the Blanks*. The final example from the course is a Complex Fill in the Blanks with embedded video for listening comprehension. In Figure 5 we see an embedded YouTube video with a listening comprehension video below. Students listen for specific legal lexical items in context and must write the words or expressions in the gaps. An information button (i) is provided for items that were considered to be more difficult to understand. Such activities can also easily be set up by the content creator to use other video formats (if not available online) and a drop-down list so students can select among several different options. This latter format has been adopted in the same course to introduce and consolidate grammatical structures.

278



Figure 4 - HP5 Flashcards activity for legal English.

3.3. BLENDED LEARNING AT UNINT

At this point we should ask ourselves whether the course presented above can be considered as an illustration of flipped classroom (cf. 2.1) and blended learning (cf. 2.2). Through the lens of the blended learning paradigm, courses on Everywhere indeed combine online educational materials and opportunities for interaction online with traditional place-based classroom methods.

A number of traditional Moodle resources such as File (to share slides, handouts and reading materials), File (to display files within the course interface or make them downloadable), Book (for multi-page resources presented in a book-like format), and URL (to share web links). In addition to these, we can find standard Moodle activities such as Quiz (for in-class assessment and final exams), as well as Glossary, Feedback, Choice, Forum, etc., which open up the course for more interactive learning. The addition of other plugins such as HP5 and Zoom further enrich the learning environment creating conditions for the flipped classroom to be put into practice.

4. CONCLUSION

Research has proved that Moodle has proven to be an effective tool for teaching purposes, and its use is rapidly developing to address various concerns and improve the learning experience. Previous scholars, however, bolstered further research in order to investigate the use of Moodle in non-STEM and non-tertiary disciplines, as well as educators' perspectives on its use.

As shown in Section 3, the incorporation of this platform into the UNINT Everywhere learning platform has led to the development of an interactive platform for both students and teachers. While authors' experience of their own course page on Everywhere has been a boon for the development of an interactive learning platform, more resources may be added to make the course even more blended. Indeed, this requires time and effort on the part of the content creator. However, our shared aim is that our students become more central in the learning process - and this may lead to a more effective learning paradigm for future university students enrolled on ESP and EFL courses.

To conclude, what began as a race to make UNINT course content and lessons more easily during the Covid-19 pandemic has now developed into a full-fledged flipped classroom and blended scenario, which offers numerous resources and activities for both F2F and online learning situations. Further studies on the use on LMS in higher education are needed, yet we firmly believe that we are moving into the right direction – both for students and educators alike.

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INFORMATION TECHNOLOGY IN TEACHING FOREIGN LANGUAGES SESSION

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SINTEZA 2023

DIGITAL TOOLS FOR LANGUAGE LEARNING: EXPLORING TEACHERS' INNOVATIVE AND ENGAGING PRACTICES

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Abstract:

This paper reports on the case study conducted with a group of secondary school language teachers and their practices of using digital tools from the COVID-19 pandemic outbreak onward. It investigates which tools the respondents used when they conducted classes exclusively online, and which ones they use when organising in-person teaching. The study aims at determining whether, how and to what extent the habit of using digital tools has improved over time. Quantitative research, in the form of an online survey, was conducted at the beginning of 2023 in order to analyse teachers' overall perceptions of digital tools in language teaching and learning before, during and after the COVID-19 pandemic. Forty-eight respondents did the online questionnaire. The findings showed that teachers held critical viewpoints on the use of technology in language teaching. The findings also suggest that teachers adopted digital technologies to address their and students' needs. Teachers reported that they found it difficult to deal with the challenges of online learning, especially regarding the lack of effective communication, staying up to date with modern technology and time-consuming administrative work. Furthermore, the results reveal that using digital tools helps students engage with the language in diverse ways, enhances their motivation to learn, develops their language learning skills, and improves their intercultural communicative competence.

Keywords:

Digital Tools, Language Teaching, Teachers' Perspective, Interactive Classroom Environment, COVID-19.

INTRODUCTION

Technological advancements have greatly influenced education policies and teaching and learning practices, providing valuable opportunities for improving the quality of education at all levels. As a result of immense changes affecting education systems worldwide, particularly enhanced after the COVID-19 outbreak, there have been numerous endeavours to reexamine the role of digital technologies in creating purposeful and effective teaching and learning.

Aiming at providing a high-quality education framework that relies on a digital environment and tools, and helping all education stakeholders tackle the digital challenges and embrace the opportunities, the EU has adopted the Digital Education Action Plan (2021-2027) in 2020 [1]. The importance of innovating and developing new ways of teaching and

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e-mail: agagic@singidunum.ac.rs learning supported by educational technologies has been emphasised in our local context as well, and the Ministry of Education, Science and Technological Development of Serbia published the Digital Competence Framework in 2019, as one of the educational policy measures regulating the application of digital technologies. The Framework focuses on developing teachers' digital competencies, and, subsequently, contributing to the development of students' digital competencies and equipping them with skills needed for living and working in a digital society [2].

The role of teachers in a technology-supported education environment is crucial, and, in order to respond effectively to the ever-growing educational demands, they need to develop their digital competencies continuously [3]. This paper reports on the case study conducted with a group of secondary school language teachers and their practices of using digital tools from the COVID-19 pandemic outbreak onward. It investigates which tools the respondents used when they conducted classes exclusively online, and which ones they use when organising in-person teaching. The study aims at determining whether, how and to what extent the habit of using digital tools has improved over time.

2. TECHNOLOGY-SUPPORTED TEACHING

In recent years, our society has experienced a technological revolution due to a global sanitary phenomenon (COVID-19), which has affected all aspects of human activity. For this reason, education has been transformed in the way that the use of technology and the Internet has become a priority in all school systems. As the use of technological tools such as LMS platforms, CMI systems, and other institutional and non-institutional webbased teaching aids became an alternative or a substitute for in-site lessons and conventional face-to-face classrooms and educational centres, teachers and students have been oriented towards developing and improving their digital skills and competencies in a relatively short period. The aim was to provide a continuous and effective teaching and learning process, accessible to all participants: educators, students, and institutions. The Internet adopted the role of a multi-directional, interactive, and creative medium, suitable for both synchronous and asynchronous interaction. The technological tools used for teaching and learning in such conditions were mainly based on Web 2.0 tools. The applications and platforms provide interaction between users, utilize data from multiple sources, and offer various audio-visual

facilities to all users connected to the Internet, delivering rich user experiences [4]. Consequently, current teaching approaches and methods have been reexamined and modified to respond to new conditions. More than ever educators have been encouraged to promote a learnercentred approach and students' active engagement in their learning. Although the panacea of the best teaching model is an elusive idea, much attention has been paid to the need to constantly adapt educational practices to the dynamic social and economic changes with the aim of ensuring the quality of teaching and learning [5]. On the other hand, such changes pose numerous challenges for teachers who need to master a wide range of skills to respond to the newly created demands arising in societies. Various aspects of teachers' digital competencies have been investigated. Findings draw attention to the discrepancies between what teachers identify as needs and priorities in technology-supported lesson organisation on the one hand and, on the other, real demands and teachers' skills and competencies [6].

A considerable body of research has investigated whether teachers in the Republic of Serbia were ready for the online teaching environment, and some show that despite adequate access to technology, the respondents, primary school teachers, were not prepared to organise lessons effectively, emphasising the lack of communication with students as the greatest challenge during online teaching [7]. The research conducted by the end of 2021 points to considerable differences in using tools and platforms when conducting and organising online lessons, reporting the findings that the commonest platforms used for synchronous online teaching were Zoom, Google Meet, and Microsoft Teams, while Google Classroom and Moodle were mainly used as LMS platforms [8]. As regards teachers' perception of the benefits of using digital technologies, opposing results can be found in research - some show that teachers do not express dominantly positive attitudes, prioritising traditional and face-to-face interaction [9], while others identified that the use of technology can facilitate lesson preparation, enhance students' motivation, and make teaching and learning material more accessible to everybody [10]. In research conducted with the aim of examining students' opinions on the possibilities online learning can offer, the results show that secondary students to a high extent recognise the advantages and possibilities of digital tools and platforms [11]. Based on the research conducted among students, the findings suggest that the primary benefit of integrating mobile applications in foreign language instruction is the engaging and stimulating nature of the learning experience [12].

All levels of education have experienced changes and teaching foreign languages is no exception. The updated version of CEFR (2020), which promotes an actionoriented approach, has introduced two new scales of online interaction: online conversation and discussion and goal-oriented online transactions and collaboration. Both scales involve multimodal activity, or use of the web, for spoken or written activities. From this perspective, the digital environment provides learners with valuable tools to express, participate and improve access and inclusion in society [12]. Those premises encourage learners' autonomy and digital competencies to prepare learners to interact independently in online intercultural environments. In such a context, teachers are stimulated to analyse their existing practices, change them, or adapt them to new circumstances. The institutions have adopted different learner-centred models such as blended or hybrid learning, flipped classrooms, game-based learning, and others, incorporating them into their learning management systems. These teaching methods and approaches are based on CALL, an interactive model that with the help of computer technology provides all stages of teaching: presentation, practice, and feedback, facilitating the learner's autonomy and self-paced learning [13]. Nevertheless, the primary focus on technology and online tools may raise numerous questions about their pedagogically justified application in language classrooms. The mere adoption of new technological equipment, hardware, and software by teachers and students has not provided necessarily qualitative teaching and effective learning of a target language. In other words, technological innovation does not imply pedagogical innovation [14]. Both teachers and learners, regardless of the educational and geographical context, recognise the advantages but also the challenges of the newly imposed hybrid language learning context. Recent studies show that face-to-face interaction and the role of the teacher are irreplaceable elements for effective language learning [15] and that lectures, presentations, and oral explanations given by professors are more effective than learning with the support of digital tools [16]. Some challenges are related to a lack of motivation for learning caused by inadequate learning environments or by technological issues [17]. Some of the evidence shows a lower interaction between the teacher and students in the synchronous online model of interaction, via a video-conferencing tool [18]. On the other hand, online language classes are evaluated as effective and motivating [19] and provide flexibility in time and place for learning. In other words, students have become more autonomous and responsible for their learning, both inside and outside of the classroom. Teachers need to ensure that their students, "digital natives", use their digital skills for learning purposes. Teachers and educators ought to develop and utilize multiple skills and knowledge (technological, pedagogical, and content knowledge), to understand, evaluate and create learning situations that are suitable for concrete teaching contexts and based on real students learning needs.

3. METHODOLOGY

This paper aims to determine which digital tools were used in language teaching before, during and after the COVID-19 pandemic, as well as what the biggest challenges for language teachers in that period were. The research was conducted at the beginning of 2023. Quantitative research, in the form of an online survey, was conducted in order to analyse teachers' overall perceptions of digital tools in language teaching and learning before, during and after the COVID-19 pandemic. The online questionnaire was done by forty-eight respondents. It included nine multiple-choice questions and two open-answer questions. The questionnaire was designed for this research, written in Serbian and teachers completed it anonymously and voluntarily. The respondents were forty eight secondary school language teachers from Serbia. They teach primarily English as a foreign language, but French, Russian, Norwegian, and German as well. Some of them teach Serbian. Most of the surveyed language teachers have extensive work experience. Almost 36% of them have been teaching for more than fifteen years whereas 33.3% of them have been teaching for more than twenty years. Only a small percentage of respondents have been teaching for less than five years.

The data from the questionnaire were analysed with the use of descriptive statistics.

The goal of this research is also to emphasise modern trends in teaching languages and to discuss the advantages and disadvantages of using digital tools in order to motivate students and decide whether or not to incorporate one or all of them into teaching curricula most effectively.



Figure 1 - Respondents' teaching experience.

4. RESULTS AND DISCUSSION

The data indicated that almost 94% of the respondents used digital tools even before the COVID-19 pandemic. Further analysis showed that around 33% of teachers used digital tools every week. On the other hand, about 40% of teachers used them several times a year. Bearing in mind the fact that we live and work in the so-called digital age, the results are not as expected.

During remote teaching caused by the COVID-19 pandemic, educational institutions, following the recommendations of the Ministry of Education of the Republic of Serbia, decided to use some of the available digital communication tools. The surveyed teachers confirmed that their educational institutions mainly chose Google Classroom. The teachers were satisfied with the options provided by this tool. They liked the possibility of creating a central home for classroom activities. Although Google Classroom is not a fully featured learning management system, it has powerful features such as creating and collecting assignments, grading assignments, and providing adequate feedback as well as returning them to students. According to the respondents, the main shortcoming of this tool is having no possibility to communicate in real-time. Besides Google Classroom, they mainly used Google Meet as a synchronous language learning tool. Respondents agreed that the use of Google Meet can be remarkably effective if it is well managed by the teachers to stimulate student engagement during lessons. A smaller number of institutions preferred Microsoft Teams.

This tool enables them to set up virtual classrooms and keep assignments organised which proved to be particularly useful. MS Teams helps teachers synchronise all their apps, documents, and resources in one secure location which can be accessed from anywhere.

Language teachers always strive to create an interactive classroom environment. With the COVID-19 pandemic and suspension of all types of face-to-face activities, including in-person education, teachers and students had to change their teaching and learning methods, regardless of whether they were experienced in and prepared for online education or not and quickly adapt to new reality which is often named as emergency remote education [20]. In the beginning, teachers struggle to motivate students in a virtual classroom. Both teachers and learners were forced to step out of their comfort zone and face not only technical problems such as audio, video, or connection issues but also a sense of isolation. With the aim of motivating students to actively participate in the teaching process in an online environment, teachers resorted to using various digital resources that were available to them. The results showed that about 83% of the respondents used digital tools more often in virtual classrooms than in traditional ones.

According to the research results, the most commonly used digital tool in virtual language teaching is Google Forms, followed by Kahoot and Quizziz. A small percentage of respondents reported WordUp as the best digital tool for teaching/learning English.



Figure 2 - Favourite Digital Tool.



Figure 3 - Using digital tools in traditional classrooms after the COVID-19 pandemic.

Almost 36% of respondents consider Google Forms to be the best and simplest tool for creating quizzes, sign-ups, and feedback forms. Google Forms can be easily incorporated into Google Classroom and teachers often use it to assess their students' knowledge either at the beginning or at the end of the class. They liked a variety of question types that can be used while creating personalized quizzes or tests. The option of inserting images, videos, and various multimedia content is especially useful when it comes to young learners.

Kahoot, sometimes referred to as a student-response tool for all platforms, is regularly used by around 10% of respondents. This game-based learning platform enables fun learning, boosts engagement, and has a positive effect on attendance and classroom dynamics.

After the COVID-19 pandemic ended, public education returned to normal. Teachers and students were brought back into schools, but surprisingly or not, almost 65% of respondents continue to use digital tools they had been using previously. They mainly use the same tools – Google Classroom, Google Forms, Kahoot, and Quizzis. Teachers reported that they found it difficult to deal with the challenges of online learning, especially regarding lack of effective communication, staying up to date with modern technology and timeconsuming administrative work.

5. PEDAGOGICAL IMPLICATIONS

The COVID-19 pandemic has accelerated the adoption of digital tools in language teaching, and the interest and need to use these tools continue to grow even as the pandemic wanes. Digital tools are progressing and improving, providing teachers with even more opportunities to enhance their students' language learning experiences. The creative use of digital tools in language teaching offers numerous benefits for language learning. Therefore, teachers need to consider incorporating digital tools into their teaching to enhance the quality of teaching and encourage independent language learning.

Here are some pedagogical implications that arise from the research conducted:

- Teachers should use a variety of digital tools to cater to the different learning styles and needs of their students. Using digital tools can help students engage with the language in diverse ways, which can enhance their motivation to learn.
- Teachers should be open to exploring innovative technologies and digital tools and develop their digital competencies to incorporate these tools into their teaching effectively and creatively. This will enable them to keep up with the latest trends and provide students with relevant and engaging learning experiences.
- Creative use of digital tools in teaching can help students develop critical thinking, problemsolving skills, and creativity. Teachers should encourage students to explore and experiment with digital tools to build their skills and confidence in using technology.
- The integration of digital tools in teaching can help teachers tailor their instruction to the individual needs of students and create a more personalized classroom experience. Digital tools can be used to monitor student progress and provide real-time feedback, enabling teachers to adjust their instruction and promote learning.

6. CONCLUSION

In conclusion, teachers should be willing to incorporate digital tools in their teaching in order to stimulate language learning. The creative use of digital tools in language teaching can provide a wealth of opportunities for students to develop their language skills, critical thinking, problem-solving, and creativity. We examined various digital tools available to teachers, including language learning apps and platforms, word processing software, social media, and more. We also provided examples of how these tools can be creatively used in the classroom to boost language learning. Integrating digital tools in the classroom enables students to connect with the language in diverse ways, boosts their motivation, develops their language learning skills, and improves their intercultural communicative competence. Additionally, these tools foster classroom interaction, leading to improved communication and social skills. Moreover, digital tools assist teachers in tailoring their teaching to the individual needs of students, thus creating a more personalized classroom experience. Furthermore, digital tools are also beneficial for formative assessment, evaluation, and tracking of student progress. Teachers can use digital tools to monitor student performance and provide real-time feedback to adjust instruction and encourage learning. Digital tools also provide a more efficient way to evaluate student work, enabling teachers to identify areas where students need more support and tailor their teaching accordingly.

In summary, the creative use of digital tools in language teaching offers many benefits for both teachers and students. By incorporating digital tools into their teaching, teachers can enhance their students' language learning, develop their digital competencies, and improve formative assessment, evaluation, and tracking of student progress.

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SINTEZA 2023 INTERNATIONAL SCIENTIFIC CONFERENCE ON INFORMATION TECHNOLOGY, COMPUTER SCIENCE, AND DATA SCIENCE

INFORMATION TECHNOLOGY IN TEACHING FOREIGN LANGUAGES SESSION

CHALLENGES OF TRANSLATION RELIABILITY IN THE ERA OF TRANSLATION TOOLS: ANALYSIS OF TRANSLATIONS FROM THE SERBIAN LANGUAGE

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Abstract:

This paper aims to explore how the use of the internet and machine tools facilitates the process of translation. Translation tools such as Google Translate, Yandex Translate, and ChatGPT were used in the research. The original text in the Serbian language was translated into five foreign languages: Russian, German, Greek, English, and French. After comparing translations into these languages using three translation tools, it was shown how internet tools can help solve translation dilemmas, as well as what their reliability and accuracy are. Thanks to translation tools and an abundance of updated information, adequate application of translation methods and procedures is enabled, contributing to the acceleration of the translation process and the improvement of translation quality.

Keywords:

Translation Tools, Google Translate, Yandex Translate, Chatgpt, Reliability, Accuracy.

INTRODUCTION

Over the past half-century, researchers have dedicated significant effort to the creation of machines or software that could replace human translation, either partially or entirely. In the present era of rapid technical and technological development, which has facilitated the quick acquisition and dissemination of information, the need for such technologies has become increasingly pronounced [1]. Information technologies have exerted a tremendous influence on the advancement of society and science, easing both personal and professional life, albeit requiring continuous monitoring of scientific progress in this domain. In this regard, the everyday use of foreign languages for professional or personal purposes necessitates active reading and writing in the target foreign language, thereby increasing the demand for translation from one's native tongue to the targeted foreign language.

The advent of the internet has revolutionized the ability to network a vast number of computers, enabling real-time communication with people worldwide and granting access to immense amounts of information stored on computer servers across the globe [2].

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This form of communication has also opened up access to an array of resources that can assist and streamline the translator's work. The utilization of machine translation technology has significantly risen in recent years for cross-border communication [3].

The relationship between information technologies and professional translation is particularly noteworthy. On the one hand, translation has historically facilitated the dissemination of new scientific and technological knowledge, while on the other hand, science and technology have significantly influenced the field of translation. It is evident that technology plays a pivotal role in both scientific and professional translation [4].

Nowadays, translators, as well as non-professionals, have access to a variety of translation tools that can assist them in their work. Translation tools encompass a range of software that facilitates the translation of written text from one natural language (source language) to another (target language). Existing translation tools can be broadly categorized into three types: fully automated machine translation, machine translation with human participation and machine-aided human translation [5].

2. TRANSLATION TOOLS

This paper shall focus on three free translation tools that are widely used today due to their accessibility, and we will aim to present their advantages and disadvantages.

Google Translate is an online machine translation service developed by Google, which uses artificial intelligence and neural machine translation techniques to translate text from one language to another [6]. Launched in 2001, Google Translate has since become one of the most widely used machine translation tools, providing translations between over 100 languages.

Google Translate is a machine translation tool that can be used to obtain basic information about the original text through moderate-quality translations. It is a popular tool due to its low cost and ability to provide instant access to general information about a text in over 100 languages [7]. As of May 2017, it is being used by over 500 million people daily and is considered to outperform other publicly available machine translation tools [8]. However, in recent years, Google Translate has increasingly incorporated neural machine translation (NMT), which uses artificial neural networks to model the complex relationships between words and phrases in different languages [9]. Yandex Translate is a statistical machine translation system that is capable of translating individual words and complete texts, and is available in 94 languages as of March 2018 [10]. The translation process relies on a translation model that contains a comprehensive list of known words in each language, along with their corresponding translations in other languages. Therefore, each language has its own unique translation model, which is built through cross-referencing translated texts and works in different languages, also known as a parallel corpus. To improve translation accuracy and context, the system continuously processes new texts from multiple sources, which is why a large number of sources are needed [11].

The introduction of a public tool developed by Open GAI – GPT or Generative Pre-Trained Transformer [12] – has brought many changes into many spheres of human endeavour. Although its capabilities, accuracy and reliability have not been thoroughly investigated yet [13], ChatGPT is frequently used as a translation tool for different purposes.

Despite its widespread use and significant advancements in recent years, Google and Yandex Translate still have limitations in terms of accuracy and naturalness. In particular, language translation software often struggles with translating idiomatic expressions, cultural references, and complex sentence structures. Nonetheless, the translation tools remain a useful and accessible tool for a variety of purposes, from basic communication to professional translation. Machine translation can provide significant assistance. However, despite the progress achieved thus far, machine translation remains unable to match the translation capabilities of the human mind. Consequently, researchers are striving to develop more sophisticated translation technologies that can reach the level of human translation ability. Advancements in translation technology can have a profound impact on how information is conveyed, both at the personal and professional levels. In the future, machine translation and other translation technologies may play a pivotal role in shaping global communication and promoting cross-cultural understanding.

3. METHODOLOGY

The topic of our research is to test the reliability and quality of text translations using digital translation tools such as Google Translate and Yandex Translate, which are mostly used, and the artificial intelligence ChatGPT, which we assume will be widely used for the purposes of translation.

The purpose of our research is to determine whether we can rely on translations of text that are not written in a scientific or administrative style but rather a newspaper article with an inconsistent style and to verify whether there are any differences in the solutions offered by the tools. We compared the results obtained and drew conclusions for each of the five languages – Russian, French, German, Greek and English.

The original text is from "Politika", a Serbian daily newspaper [14].

4. ANALYSIS AND DISCUSSION

4.1. RUSSIAN LANGUAGE

In terms of understanding the translated text, it can be concluded that all three tools translated the text in such a way that its meaning was conveyed entirely in Russian, with a few significant errors.

Regarding the use of words in grammatically correct forms, it was expected that the translation tools would make a significant number of errors, but analysis showed that there were no morphological errors.

Furthermore, it can be noticed that broadly speaking, they are correct, but there are also places where the word order is not in the spirit of Russian, but rather follows the word order in the Serbian text.

When examining texts translated with the assistance of these tools, it is noticed that all three translations are quite different. Also, the title of the news is translated differently in all three texts, but the meaning is correctly conveyed.

The sentence that represents the project name " I mede i med – da uvedemo red" contains a diminutive that was expected to be an "issue", which was confirmed. The project name appears in the second and last paragraphs and it is translated differently. Yandex had the same and wrong translation in both places, that is, the word "cub bear" was translated as "honey" while Google and ChatGPT correctly translated the word as "cub bear" in one place and the word "honey" in the other.

If the entire project name is considered, the best translation is provided by GPT at the end of the text.

All three translations are correct, but the most reasonable one is ChatGPT since the term "Zlatiborci" is translated as the phrase "residents of Zlatibor," while with the others, it would be necessary to explain in a footnote who "Zlatiborci" are. Google left the noun in the nominative case, as a foreign word that has not been translated. One of the drawbacks is also the translation of the text containing words or sentences in a language that is not specified to be translated from, these tools translated it into the specified language. There is a sentence in the text in English that all three tools translated into Serbian, but the quotation marks were different. ChatGPT and Google Translate used so-called French quotes («»), which are very common in Russian spelling, while Yandex used upper quotes (""). One should be careful and not translate parts of the text that are not in the specified language integrated with the rest of the text. Everyone can boast respect for spelling rules. Only one major error occurred in the analyzed text, where the translation tool (Google Translate) divided the sentence or used a period where it cannot be.

Having mentioned everything above, it can be said that today's translation tools can greatly help a person understand a text that has been translated from Serbian to Russian, but the text gained as a result of machine translation still cannot be considered completely accurately translated.

4.2. FRENCH LANGUAGE

Based on comparative analyses of the translation of the given text, it can be concluded that all three tools managed to translate the text into French so that the meaning has been fully conveyed. However, there were several translation errors, especially in style and conveying the spirit of the language. Moreover, two tools – Google and Yandex, have retained the structure of the Serbian language more, while GPT used structures characteristic of native speakers of the French language more successfully, thereby contributing to the quality of the translated text. This tool also used the most appropriate choice of words in line with the given context.

It was expected that the translation tools would make a significant number of errors in the use of words in the grammatically correct form. However, the analysis revealed that there were no morphological errors. Observing the sentences obtained by machine translation, they are generally speaking correct. However, there are places where the word order is not in line with the French language but follows the word order present in the Serbian language, especially with the Google and Yandex tools. For this reason, the translation of these two tools is more clumsy and less receptive to the French language system. ChatGPT managed to adapt the word order that is unique to the French language and thus translate the text harmoniously.

When analyzing texts translated using these tools, it is noticeable that all three translations are different, i.e., different words and phrases were used during the translation of the same parts. What is interesting to note is that the title of the news was translated differently in all three texts, but the meaning was successfully conveyed. The title translation using the GPT tool is still mostly in the spirit of the French language.

The name of the project "I mede i med - da uvedemo red" contains a diminutive word that was a challenge during translation and this was confirmed. The name of the project appears in the second and last paragraph and was translated in different ways. Google translated the same phrase that appears twice differently. In the first case, it was translated as two bears, although the number two is not mentioned but it recognized that it was a noun in the plural and used the plural article. In the second case, it did not differentiate between "mede" and "meda" and translated both terms as "med". Yandex gave the same and incorrect translation in both cases, i.e., the word "meda" was translated as "med". GPT correctly translated in both cases, making a distinction between the diminutive "meda" and the noun "med". If we look at the entire phrase "I mede i med - da uvedemo red", the best translation is with the help of the GPT tool during the first occurrence in the text. It should be noted that the tools do not always translate the same phrase in the same way in the same text.

For the term "Zlatiborci," we have concluded that all three translations are correct. The most understandable translation is via GPT because the term "Zlatiborci" was translated as the phrase "residents of Zlatibor," so even for those who do not know that Zlatibor is a toponym, this tool explained that they are residents of that place. With the other two tools, it would be necessary to explain in a footnote who "Zlatiborci" are. Google left the noun in the nominative case, i.e., as a foreign word that is not translated. Google left the noun as it is, while Yandex translated it as "Zlatibor residents."

One of the problems with translating text is when the source text contains words or sentences in a language that is not specified to be translated, and machine tools have translated them into the specified language. For example, there may be a sentence in English in the text that Google and Yandex have translated into French, while GPT has left the sentence in English, as it appears in the original text. It is important to note that it is necessary to pay attention and not translate parts of the text that are not in the specified language, and they should not be integrated with the rest of the text. This tool left the noun as it is in Serbian, however, it did not leave it in the dative as in the text but put the noun in the nominative, its base form since French does not recognise the case system. Yandex correctly derived the name of the inhabitants, using the formative ending for the plural of nouns denoting the inhabitants of an area -iens.

It is important to emphasize that spelling rules have been respected. Speaking of the use of quotation marks, all three tools used upper quotation marks according to the French spelling system. When it comes to the use of commas, Google and Yandex left them as they were used in the original Serbian text, while GPT adapted them to the French spelling system.

After analysing the above examples of translating from Serbian to French using Google Translate, Yandex, and ChatGPT, we can conclude that today's translation tools play a significant role in facilitating the understanding of texts in other languages. However, despite their advantages, we should be cautious while using them, as translation errors can sometimes occur, leading to an incorrect interpretation of the text. As we have seen in the previous examples, each of these translation tools has its advantages and disadvantages. It is also important to keep in mind that other types of errors occur in the translation process, such as the incorrect interpretation of phrases, inaccurate translations of idioms, etc. Therefore, before using any translation tool, it is necessary to check the quality of the translation and, if necessary, adjust the translation to avoid any ambiguity and misunderstanding of the text.

Translation tools are useful and practical for translating texts quickly, however, they cannot replace human knowledge and the ability to understand language. Therefore, one should always be cautious when using these tools, checking the quality of the translation and comparing it to the original text to ensure the translation's accuracy and comprehensibility.

4.3. GERMAN LANGUAGE

By examining the understanding of the translated text, it can be concluded that all three tools translated the text in a way that preserved the meaning of the text as a whole. However, errors that were noticed and identified could not be logically linked to the text.

Regarding the use of words in grammatically correct form, it was expected that the translation tools would make a significant number of mistakes, but this did not happen.

In terms of syntax, it can be concluded that in some places the sentences were translated literally, which was least noticed in ChatGPT.

When looking at texts translated with the assistance of these tools, it is noticeable that all three translations are understandable but translated in a different way. It is interesting to note that the news title in all three texts was translated differently, while the meaning remained unchanged.

Regarding the sentence that represents the name of the project "I mede i med – da uvedemo red", it was noticed that Google translated the phrase correctly into English in the first part of the text, but in the other part of the text (the same phrase) into German without making a distinction between "mede" and "meda". Yandex had the same mistake in both places, while ChatGPT replaced the word "mede" with the word "bees" in the first part of the sentence and correctly translated it in the second part, thus making a distinction between the words "mede" and "med".

All in all, all three translations are correct, however, the translation provided by Yandex is the most understandable as it translated the term "Zlatiborci" as "Zlatiborcima" and thus put the noun in the genitive plural, while Google left the noun in the nominative. ChatGPT transformed the sentence and put the noun "Zlatiborci" in the genitive plural. It is necessary to emphasise the accuracy regarding spelling rules. In the analysed text, one translation tool (Google Translate) divided the sentence, or used a period where it should not be put.

It is concluded that translation tools can translate the text as a whole and be a good support, but such translated texts still cannot be considered as a complete and entire translation, so it is advisable to be cautious when using the analysed translation tools. The advantage of using translation tools is that they provide more translation solutions.

4.4. GREEK LANGUAGE

The text translated from Serbian to Greek using all three tools is understandable with a larger number of significant errors. Most errors are morphological, when it comes to the use of articles before nouns and adjectives, which then leads to errors in declensions. In terms of syntax, the tools translated sentences literally, so in many sentences, the meaning was changed.

The sentence that was in English in the text was translated into Greek in all three cases.

The sentence that represents the name of the project "I mede i med – da uvedemo red" contains a diminutive for which we expected it to be a "problem" during translation, which was confirmed, only ChatGPT translated the word "meda" as "cub bear" while the other two tools translated it as "honey."

The word "Zlatiborci" was recognised by all three tools, translated as "residents of Zlatibor."

4.5. ENGLISH LANGUAGE

Having analysed all the translated solutions by all three translation tools, it can be concluded that all the tools provided a meaningful translation of the text. Even though it has been assumed that there would be a significant number of mistakes in terms of grammar and morphology, the tools translated it with few errors.

The best solutions were provided by ChatGPT since it used the structures of the English language, translating the text in accordance with the very language. Google and Yandex mostly followed the structure of the original text, translating the text literally – word-for-word from Serbian to the target language. It is interesting to mention that all the tools provided different solutions for almost all the parts of the texts. However, the overall meaning remained unchanged.

The name of the project "U меде u мед – да уведемо ped" seemed to be the greatest issue. Each tool recognised a diminutive for the word "bear" as "honey", thus it has been wrongly translated by the analysed tools.

Another issue was the name of the inhabitants of Zlatibor – each tool has a different solution for the word "Zlatiborci". Google kept the base form of the word "Zlatiborci", although it can be seen in the genitive case in the original text as "Zlatiborcima". Yandex suggested adding the suffix -ians, while ChatGPT translated this word as "people from Zlatibor".

292

Speaking of punctuation, Google and Yandex leave the signs where they originally are in the text. On the other hand, ChatGPT pays more attention to this segment putting the signs in accordance with the language.

Taking everything into consideration, the texts gained as a result of machine translation are understandable and can help one in understanding the overall meaning of a translated text. Using these methods to translate texts is time-efficient as well. However, machine translation is not the most reliable way to translate from one language since there is still a lot to be improved, especially in the style a machine uses while translating.

5. CONCLUSION

The use of machine translation has become increasingly common nowadays due to an increased need for intercultural and international communication. Even though, these translation tools can be useful for basic communication and understanding, they are not always accurate and sometimes may not be able to convey the meaning in the target language entirely. Furthermore, relying on translating tools can easily lead to miscommunication or misunderstandings.

In this paper, it is concluded that translation tools can provide a complete translation of the text and that they could be good support. Nevertheless, texts translated in this manner still cannot be considered completely and accurately translated, thus it is advisable to be cautious while using the analysed translation tools.

As one of the greatest advantages of using translation tools, we would highlight providing multiple translation solutions. Translation tools are useful and practical since they are able to translate a text quickly, faster than a human being. Still, it is impossible to replace human knowledge and their language comprehension abilities.

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SINTEZA 2023 INTERNATIONAL SCIENTIFIC CONFERENCE ON INFORMATION TECHNOLOGY, COMPUTER SCIENCE, AND DATA SCIENCE

INFORMATION TECHNOLOGY IN TEACHING FOREIGN LANGUAGES SESSION

DIGIDAZU - A PORTAL FOR LEARNING THE GERMAN LANGUAGE IN A BUSINESS DIGITAL ENVIRONMENT

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Abstract:

In the digital age, the age of using smartphones and the Internet in learning and acquiring foreign languages, the digidaZu application represents another tool for a completely new and creative way of learning German. Along with other tools such as Hello Talk, Duolingo, WordUp, Kahoot, and the Easy German language learning channel, this platform does not represent a complete innovation. On the other hand, what sets this application apart from others is that the language it teaches is the language of profession, i.e. Business German. As an example, exercises are tailored to the language of the office (scheduling appointments, ordering goods, entering data into Excel spreadsheets, business phone calls, codes, office supplies...). The research was conducted to explore students' attitudes towards this very useful portal, what its advantages and disadvantages are and what could be improved and upgraded on this platform, as its development is still ongoing.

Keywords:

Learning German, English for Specific Purposes, Business German Language, Digital Environment.

INTRODUCTION

The digital age has brought about significant changes, both in the business environment and in everyday life. The use of mobile phones has completely transformed our way of life and brought with it many good and bad habits. As an advantage, we can highlight the possibility of learning anywhere and at any time, and the availability of learning materials. On the other hand, as a disadvantage, students' attention is reduced due to the constant influx of information. Students become distracted and are unable to follow the course of the lesson for a long time, and this presents a problem at all ages. In the business world, the situation is the same. Everything is being digitized, and someone who does not know how to handle online tools would not have great chances of developing a career.

DigidaZu is a platform that is applicable on mobile phones as well as on other devices (tablets, laptops, computers). At any time and in any place, students have the opportunity to learn new words and expressions and develop their German language skills. According to Krželj and Hartweger, the implementation of mobile learning greatly facilitates the learning of the German language among young people [1:97].

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The emphasis here is on listening (Hörverstehen), reading comprehension (Leseverstehen), completing words, connecting content, learning through images, and speaking skills, while writing longer texts is not the main focus of the DigidaZu application. If a student wants to focus more on oral communication or wants to find a conversation partner in German, French, or Spanish, for example, then the Hello Talk application would be more suitable for them, as described in the paper of Maenza and Gajić [2:642-643].

Our interviewees are students of the Faculty of Business, the Faculty of Computer Science and Informatics, as well as the Faculty of Tourism and Hotel Management at Singidunum University. Each of the mentioned faculties has a completely different language for specific purposes. The platform offers exercises that are oriented towards topics related to various professions. We will only mention some examples - the language of pharmacy, language in the office, in a nursing home. The common thing in all exercises is learning about German business etiquette and cultural specificities. In the global world, cultural habits become less pronounced, but again, if a student were to work in a German, Austrian, or Swiss business environment in the future, it would take them time to adapt to some of the habits and specificities of the above-mentioned environments. The platform highlights the Austrian way of business communication the most, as the project originated from there. According to Ivić, English should be taught as a language for specific purposes from the elementary level [3:52-53]. The same should be the case for each foreign languages. Since language is infinite, it should be studied with guidelines and directions from the very beginning. According to Jelovčić, the subjects' attitudes show that each student should speak at least two foreign languages [4:49] - English and another foreign language. With language learning, the culture of the target people is also studied. The authors Didović Baranac, Falkoni-Mjehović, Vidak dedicated their work to the attitudes of the subjects in the language of the profession. They compared attitudes towards learning German, English, and Spanish in a business environment [5:16-17]. Here we will highlight the results related to learning German. A large number of respondents state that (Business) German is difficult to learn and that it is best learned by staying in the German-speaking area.

Enabling people to enter the world of business everyday life that is digitalized was the initial guiding idea for the creation of the digidazU platform in January 2020. Learning German is simultaneously connected to acquiring basic digital competencies. This enables users of this platform to participate and integrate faster into social life and the labour market. [6]

Let us take a brief look at the digidazU platform itself. DigidazU comes from the words "digi," which refers to digital, "DaZ," which stands for German as a second or foreign language, and "Zu," which shows that it is a combination of both.

According to source [7], the project was created by an integration centre in Vienna and aimed primarily to help foreigners integrate into the business world. From this idea, the platform became available not only to foreigners but also to anyone who wants to learn business German. Enabling people to enter the world of digitalized business everyday life was the guiding idea for the creation of this platform in January 2020.

From source [8], we learnt that even those who speak German well can sometimes find it difficult to use it in a business environment. Not because of a lack of knowledge of the language, but because of insufficient proficiency in the tools that this platform tries to bring closer to the average user.

From all the above, we conclude that this research is useful and will open up a series of ideas and questions for further research on the same topic.

2. RESEARCH AIMS AND HYPOTHESIS

As we have already stated, the aim of the research was to examine the attitudes of students from non-linguistic faculties towards the advantages and disadvantages of the digidazU platform. There are a few hypotheses we set:

- It is assumed that the most demanding exercise will be listening due to the speed of speech and the subject of conversation.
- It is assumed that the application is useful for students preparing for the future business environment.
- It is assumed that the student has enriched their vocabulary with at least six new words/expressions after completing the exercises.

3. PARTICIPANTS

Our participants were students from non-linguistic faculties at Singidunum University, namely the Faculty of Computer Science and Information Technology, the Faculty of Business and the Faculty of Tourism and Hotel Management. The participants were from all over Serbia, not just from Belgrade. They had prior knowledge of the German language and no one was at a beginner level. We had male and female participants, making our sample diverse and relevant. The research conducted was a qualitative study in the form of a focus group. The focus group consisted of 7 students who had been introduced to the digidazU platform during class and in their free time, and were asked to answer the questions provided in this study. The interviews were conducted anonymously, so participants were encouraged to express their opinions honestly and critically. The authors of this study chose this method of research in order to examine students' attitudes towards the functionality, applicability, and potential shortcomings of the platform in a more intimate and relaxed manner.

4. RESEARCH RESULTS

Speaking of the first question – whether the exercises follow business trends and whether the acquired knowledge is applicable in practice, all participants gave affirmative answers. Since one of the multiple thematic areas offered by the application was chosen, in our case Im Büro, the participants recognize the possibility of applying the acquired knowledge in various business profiles: business secretary, administrator, employee in a tourist agency, etc.

Five participants named exercise number 3 (matching cards with similar meanings) as the most challenging exercise, with the following explanation: S.M: There are many new unknown words, and even the possibility of seeing the correct answer later does not contribute to understanding. Therefore, he believes that sentences should be shorter and simpler, and the option of combining two cards should have the ability to zoom in.

Most participants (5) named exercise 1, the listening exercise, as the easiest, with the explanation that the speech tempo was acceptable because they often listen to audio exercises in regular classes that they only partially understand due to inadequate speech speed. It is important to note that the topic of the listening exercise is scheduling appointments, changing and rescheduling appointments, and several dates within a short time frame. Hence, there is a need for greater concentration. A.O made an interesting observation that both female voices leading the dialogue have a similar tone, which confuses the listener at some point, so it would be more effective if they were different voices or even better, male and female voices.

When asked to name a few new words, three participants listed five or more words they remembered. It is noticeable that they are almost the same words or phrases. These are: die Bürokauffrau; der Marker, abtippen, einen Termin verschieben, absagen. In addition to these, A.O mentions phrases such as Buchhaltung machen; Leider ist alles voll; S.M also mentions nouns that are the subject of the 4th exercise: der Notizblock; der Stempel, die Klammermaschine. M.I and V.D emphasize the need to repeat the exercise several times to memorize the nouns related to office material.

As positive aspects of the exercises, half of the participants mention the following:

- 1. Variety (pictures, animations, audio, video)
- 2. Symbols that lead to additional exercises or situations typical in a business environment with a single click
- 3. Easy to repeat and check mistakes
- 4. Exercise 4 (learning vocabulary using pictures) is very useful and simple to learn vocabulary, especially since the singular and plural forms are given for nouns, and the infinitive and one example sentence.
- 5. Applicability in practice
- 6. Orientation towards communication in a business environment

The participants do not name any characteristic as exclusively negative regarding the exercises given, but they recognize room for improvement. Therefore, it is more about suggestions for improving learning efficiency.

Before Exercise 2 (Complete the text with the given suggestions), there should be an explanation/rule presented through an example sentence when using a specific preposition. (A.O notes that she had a dilemma when to use the preposition "bei" and when to use "vor".)

In Exercise 4, in addition to the noun, there should be the possibility of an audio recording (for example, via a speaker symbol) to be able to hear the correct pronunciation of a particular word because there are many compound words. The ability to see an image, text, and sound contributes to faster the faster acquisition of words.

New fields such as accounting (with specialized terminology), trade, tourism, and hospitality should be introduced. (B.K, V.LJ, A.O)

At the end, we will turn to the set hypotheses and the goal of our research.

• It is assumed that the most demanding exercise will be listening due to the speed of speech and the subject of conversation.

This hypothesis is partially confirmed. Only one respondent, V.LJ, stated that listening was the most challenging, while most respondents stated that the exercise with connecting cards was actually the most challenging.

• It is assumed that the application is useful for students preparing for the future business environment.

All respondents confirmed this hypothesis. They stated that the application is excellent for learning Business German. It should be noted that this platform is still in development, and new topics shall be introduced.

• It is assumed that the student has enriched their vocabulary with at least six new words/expressions after completing the exercises.

This hypothesis was proved wrong, thus we can say that some respondents learnt more than six new words/ phrases. It is important to note that several respondents stated that they would need to repeat the new words several more times, which indicates that a new word/phrase is considered learnt only after several repetitions.

5. CONCLUSION

Besides the English language, which is a lingua franca, German language has gained more popularity and importance in the business world. Many German/Austrian/ Swiss companies, banks, and corporations have opened up in our area. The majority of investments in the Republic of Serbia in recent years come from Germany. Therefore, Germany is undoubtedly the biggest investor, with many of our people employed in their factories, and the interest continues to grow. On the other hand, many people from our country are leaving to live and work in some of German-speaking countries. Hence, in recent times, the necessity of knowing the German language seems more crucial than ever alongside English.

Research on a focus group showed that digidazU platform represents an excellent way to learn business German language and integrate into the business world and society. Learning the language for various jobs and acquiring digital competencies is the main advantage of this platform. Training language and digital competencies simultaneously in an authentic context is what digidaZu allows.

It is essential to mention that the number of participants in this research was relatively small, and exercises were taken from one of several thematic areas, specifically the one related to the office (Im Büro). Through the research results, several very specific constructive suggestions for improving interactive exercises in this thematic area were obtained. Additionally, in one of the next research, the language of pharmacy, gastronomy, or another area could be taken as a sample. In this sense, this research opens the door for future research focused on the German language in business.

6. APPENDIX – FOCUS GROUP QUESTIONS

- 1. Does the topic of the assigned exercises follow business trends?
- 2. Is the acquired knowledge applicable in practice?
- 3. Which of the assigned exercises was the most challenging and why?
- 4. Which of the assigned exercises was the easiest?
- 5. Can you name a few new nouns/verbs/expressions/phrases that you memorized while doing the assigned exercises?
- 6. What do you see as the positive and negative aspects of these exercises?
- 7. Is the speaking speed in the listening exercises adjusted to their understanding?

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INFORMATION TECHNOLOGY IN TEACHING FOREIGN LANGUAGES SESSION

FLIPPED CLASSROOM: PROMOTING ACTIVE LSP TEACHING AND LEARNING

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Abstract:

This study aims to draw attention to the flipped learning model, which can be beneficial for various teaching subjects, including the language for specific purposes (LSP). This paper, following the results of existing teaching practices, recent studies, and qualitative research conducted, aims to examine the advantages, limitations, and solutions for the effective implementation of flipped LSP learning in higher educational contexts. The main purpose is to determine the potential benefits of the flipped classroom in promoting more active language teaching and learning and to facilitate solutions for its effective implementation. Additionally, it presents digital tools for both, synchronous and asynchronous learning, that can be utilized with the institutional LMS platforms. The students' perception of the flipped model and LSP provides valuable data for this research. The findings reveal the positive impact on the learning experience and satisfaction at a higher education level, which can reflect on learning outcomes. However, challenges are observed in regard to asynchronous interaction, such as digital distraction, technological issues y non-relevant learning material. The study facilitates ideas on how to perform instructional stages: presentation, practice, assessment, and feedback using determined digital tools.

Keywords:

Flipped classroom, Active teaching, Active learning, LSP, Digital Tools.

INTRODUCTION

A technological revolution impacted all educational sectors during and after the global sanitary crisis (COVID-19). As a result, the Internet and digital aids became a priority in all school systems. Teachers and students have been oriented in a relatively short period of time towards improving their digital skills and technological competencies. One of the main reasons was the adoption of learning management systems (LMS), and other teaching aids as an alternative for synchronous lessons and conventional classrooms. Online environments include a variety of tools that assist the educational processes. Discussion boards, streaming media, asynchronous environments, real-time chat, instant messaging, social networking, and many collaborative and interactive tools collectively named Web 2.0. take part in the teaching together with textbooks, worksheets, and other traditional materials [1]. The CEFR- Companion Volume fosters actionoriented teaching and learning, and emphasizes interaction and collaboration through online dialogue and discussion, using the Internet for spoken or written tasks [2]. Such concepts promote autonomy and digital competencies of students and learners' active participation in the teaching and learning process. In that context, teachers are encouraged, within proposed frameworks for teachers' knowledge, to develop multiple skills, such as digital or technological, besides the linguistic, pedagogical, and content-related competencies [3].

Technology-enhanced language learning enables learners to develop their language skills using web-based tools and the Internet. One of the recent pedagogical learner-centered models within the blended and hybrid learning environments is a flipped classroom.

2. FLIPPED CLASSROOM AND TECHNOLOGY-ENHANCED LANGUAGE LEARNING

Different interactive learner-centered methods, such as active learning, collaborative learning, game-based learning, and blended or hybrid learning aim to provide effective teaching processes with improved learning outcomes. Therefore, educators and institutions have incorporated LMS platforms to facilitate an effective application of interactive teaching methodologies in virtual environments.

Additionally, studies reveal the positive impact of technology and the online environment on students' satisfaction, engagement, and progress in learning [4]. In the context of foreign or second language learning, using different kinds of technology can have positive impacts on students' progress in EFL/ESL, within different educational contexts, providing an enjoyable language learning environment [4]. Consequently, Computer Assisted Language Learning (CALL) or Technology-enhanced language learning (TELL) has the potential to provide autonomous and self-paced learning, allowing teachers and learners presentation, practice, feedback, and evaluation [5]. One of the innovative teaching models based on TELL and active learning is the flipped classroom or the flipped learning methodology. The methodology gained popularity in educational contexts in 2006 when Jonathan Bergmann and Aaron Sams started to employ this original way of teaching in their subject of Chemistry, to "rich every student in every class, every day". This model is supported by the use of technology and blended learning environments,

in both, synchronous and asynchronous forms of interaction. It promotes an inverted structure of the traditional classroom: lessons should be done at home and homework or practical activities in class [6]. In other words, learners are encouraged to learn autonomously, outside of class, the content provided by a teacher, in the form of video lesson or video presentation (grammar, vocabulary, introduction to the new topic, etc.), and the class time is dedicated to practice, conversation, and problem solving through active participation and collaboration between peers and teachers. In that context, teachers ought to create suitable learning situations applicable to the specific class and respond to students' learning styles and strategies. Studies reveal that flipped methodology and TELL have a positive impact on the development of language skills and learning outcomes: outside of class, during self-teaching periods, for reading, writing, and audio-visual comprehension skills [7], [8], an oral performance or speaking skills can be improved in the class-time period [9]. Flipped learning can have a positive effect on overall students' language learning outcomes [10].

3. FLIPPED LSP LEARNING

After COVID-19 pandemic has not only increased the use of technology for language teaching and learning but demand for virtual courses. This fact is easy to observe in international congress and publications where prevail research on the use of digital tools and learning in online environments. Flipped learning is a model that incorporates online interaction combined with virtual or inclassroom. The asynchronous interaction is supported by LMS platforms and offers students a range of study materials: video lessons, presentations, e-books, interactive exercises, assignments, quizzes, games, and others. One of the most prominent benefits of such an environment is time adaptability. The flexible time management allows self-paced learning and developing a variety of language and other skills, including digital, collaborative, and critical thinking skills. Additionally, other benefits are recognized, besides the schedule elasticity, such as accessibility, equity, and inclusion, as well as greater academic outcomes and strengthened student retention of the learning content [11]. In the LSP context, the aim is to improve the language skills in a specific field, but also the macro-skills and micro-skills related to the specific area of the use of language [12]. To implement effectively the flipped LSP model, four aspects should be followed: flexible environments, professional educators, intentional culture, and learning culture [13].

Additionally, it is necessary to determine a need analysis, analyze the specific discourse and formulate the curriculum [14]. The essential aspect of the flipped LSP classroom is related to strategies based on communication aspects in specific fields (business, medicine, tourism, diplomacy, tourism, etc.). On the other hand, the main protagonist of the learning process is a student, who is actively engaged in learning. The multidisciplinary character of language teachers is indispensable because they must develop, the target language, range of socio-linguistic competences in order to prepare students to communicate in the specific professional fields. Therefore, it might be a complex task, to develop effective teaching strategies and design meaningful material that encourages students to focus on learning, minimizing the potential for digital distraction [15]. Therefore, it is necessary to enhance curiosity through critical thinking with attractive content, enabling communication or interaction through learner-centered activities [16].

The solution for effective teaching performance in LSP is related to constant scientific updating and teachers training in technological and pedagogical aspects since the flipped courses have gained popularity in a range of educational systems. Besides active learning it is crucial to encourage active teaching, to determine the typology of effective materials and engaging activities, and to provide valuable and immediate feedback in each activity, observing continuously the progress of learners [17]. The students of LSP courses are in most of the cases adults, professionals, or students of different study programs (Economy, Medicine, Tourism, HR, Sport).

4. DIGITAL TOOLS FOR THE FLIPPED LEARNING

Selection and evaluation of learning and teaching material (LTM) should be based on the previous need analysis and learning style analysis of students. The engaging tools must enhance interest and attention and be rich in learning content. The students should be enhanced to develop both linguistic and other skills, such as critical thinking, collaborative and digital skills. There should be a possibility for self-assessment with interactive tools that provide immediate feedback as well. Regarding the potential challenges, certain students feel motivated in the self-paced learning model, but, on the other hand, other students can feel alone and easily bored with the course. Therefore, tasks, materials, and tools should be various and adaptable to respond to all types of learners, and specific course topics. The solution is the creation of personal, purposeful, and context-based material, for both, synchronous and asynchronous learning. Such a task is complex and requires additional teachers' time, effort, and multidisciplinary competencies. Fortunately, some of the digital tools that were proven effective in the existing teaching practices do not require advanced technological knowledge, and will be presented as an example:

- LMS platforms (Google Classroom, Microsoft Teams, Edmodo, Blackboard, and others). This institutional multi-functional tool enables all stages of teaching process: presentation, practice, communication, assignments and feedback. It allaws the incorporation of various materials and information, links, presentations and documents. It facilitates communication via chat and video-conferencing tool.
- 2. Edpuzzle. This platform is flipped classroom friendly tool. It offers video editing and formative assessment features that enable teachers to organize their video lessons and provide to students a reading, writing, speaking and listening practice. Teachers can use ready-made video materials or create their own video lesson with personalized questions and tasks.
- 3. *Flipgrid* A website that enables teachers to create personalized collaborative tasks ("grids") in form of the message boards, to foster video discussions among students on selected topics, facilitating an active participation and speaking activities.
- 4. *Ted-Ed.* This on-line library contains original educative videos, and it is an international platform for teachers to create their own interactive lessons. The lesson includes a title, an introduction, a range of multiple choice or open-ended questions, suggested additional resources, interactive class discussion, and a final task. The use of this tool facilitate the practice of reading, writing, speaking and listening skills, with a numerous relevant topics.
- Nearpod This digital tool enable teachers to create interactive presentations, facilitating multimedia learning and formative assessments. It contains quizzes, polls, videos, collaborate boards, and other tools that permit design of personalized teaching tasks and materials.
- 6. *Learningapps* -A versatile multi-tool platform that enables teachers and students to create and use a variety of interactive multimedia activities.

Teachers can create their own activities, based on a variety of templates for interactive learning or practising of any teaching content (grammar, vocabulary, listening, reading, etc.)

7. *Kahoot and Quizizz.* Both are online quiz maker tools that facilitate presentations, practise, assessment and feedback in the form of game-show. Teachers can use and adapt ready-made learning quizzes or create their own activities. Both tools are used among language teachers for formative assessments, assignments or in-class activities.

All presented tools are accessible on any device which is connected to the Internet. They are interactive, multi-modal and can include audio-visual features. The suggested web-based tools are teacher-friendly and permit their creative use, as well as adaptation and design of personalized materials, tasks, assignments and assessment activities. The created activities can be shared with students and performed either synchronously, in-class, either asynchronously, out-of-class, in accordance with concrete teaching and learning objectives.

5. METHODOLOGY: QUALITATIVE ANALYSIS-FOCUS GROUP

The aim of this study is to identify the benefits, drawbacks, and solutions for the flipped LSP learning model. For this reason, the study suggests effective tools to encourage active teaching and learning to improve learning outcomes. Consequently, additional research was conducted to illustrate the opinion of potential direct users - university students of different programs and professional orientations who also share a range of common characteristics. The selected students attend lessons in a hybrid learning model, both synchronously and asynchronously, at the same university (Singidunum University, Belgrade, Serbia). They learn two foreign languages: English (as a required subject during the four-year study period), and a second foreign language of their choice (Spanish, German, Italian, Russian, Greek, and French). It is important to emphasize that all students learn both foreign languages in the general language courses. Consequently, the paper provides a qualitative analysis in the form of a focus group as valuable information that reinforces research data. The authors adopted this research method, based on interviews, to collect different students' perspectives on the topic of relevance, in a more open, informal, and relaxed way. The participants in the focus groups are six students (two male, four female), representing various

study fields and professional orientations: Business Administration, Human Resources, Sport Management, Tourism and Hospitality, and Information Technology. Five students attend programs conducted in Serbian and one of them is enrolled in the international program. The participants share various common characteristics that relate them to the topic of the research: all of them are students of the same educational institution, they are similar in age (19-23 years old) and all students are learners of both, English and Spanish as their foreign languages. Furthermore, the chosen students are interested in different professional areas and attend lectures on a regular base, in a synchronous form. The learners were highly motivated to participate in the discussion within the focus group because of the topic's relevance and the opportunity to openly express their opinions on issues that were significant to them.

The discussion questions were the following five:

- 1. Do students understand the meaning of LSP?
- 2. Would they rather choose the LSP course instead of the general language course? Why?
- 3. Are the students familiar with the concept of Flipped Classroom?
- 4. Do the students believe that the Flipped model could be an effective and functional teaching model in their university context? Why?
- 5. What benefits and challenges are included in flipped LSP learning?

Regarding question 1, about their associations with the LSP, the participants were cohesive in their answers: no one of the students was familiar with the actual concept of language for specific purposes. One student related it with the use of language in particular linguistic variations, and another one connected the LSP with historical development and language influences. After they were informed about the meaning of the concept and its pedagogical purposefulness in the language educational contexts, students agreed that English is a necessary language for them, and affirmed that they would appreciate the possibility to attend ESP courses to acquire relevant language and communication tools for their future employment, with reference to the specific disciplines, focusing on technical, scientific, business, tourism, and other related aspects. When asked the same question about Spanish, students pointed out that for this language, they prefer to acquire basic but effective knowledge and skills, to understand and communicate in general social contexts.

In respect of question 2 and the potential replacement of general language courses with the LSP, five of six participants agreed that general English is necessary for the beginner courses, but prefer LSP for more advanced levels (third and fourth academic years). One student affirmed that the LSP would be beneficial from the first beginning, in the field of Sports discipline, due to the student's previous knowledge. However, participants were cohesive in their opinion, agreeing that English for Specific Purposes is more significant for their further language education since they have the general pre-knowledge of English. Participants would prefer the university classes to be specifically oriented to the professional language, that can be applied in the job environments. In answer to question 3, if they are familiar with the flipped learning model all participants affirmed that it is a completely new concept for them. Once they understood the flipped classroom premises, with prioritization of active learning and speaking in class, and self-teaching at home, and outside of class, all six participants said that have never experienced such a way of learning and expressed positive reactions regarding this innovative model. With reference to question 4, the students pointed out that the flipped approach, as "something new" might be interesting and motivating for students. It would allow self-paced learning and autonomy for every learner, particularly in the case of more "theoretical subjects". The participants agreed that for better learning would be more effective to read or watch recordings and lesson presentations at their pace before class, and then, during class discuss with peers and professors, solve problems, or demonstrate the practical application of knowledge. Finally, in answer to question 5, the students recognized many advantages of learning a language within an inverted model, such as learner autonomy, accessible material to everyone, flexibility in time and space, and self-paced learning. They also positively valued the benefits of this model for students and teachers' flexible "class-time management", related to preparation out of the class.Nevertheless, according to the focus group participants, their positive attitude about flipped classrooms has been restricted with regard to language learning, especially to language for specific purposes. In regards to disadvantages, the participants agreed about several challenging aspects of flipped LSP learning. Primarily, it might be very challenging to learn a second language oriented to a specific discipline, autonomously and online, owing to specific language aspects - grammar, vocabulary, skills, and other elements, that are incorporated into particular language and communication premises within specialized areas (tourism, hospitality, sport, business, IT and economy sectors). Students prefer to be thought by their language teachers, synchronously (face-to-face or virtually), and provided with clear explanations, instructions, and examples. The students affirmed that individual learning and self-teaching in online asynchronous mode can be challenging, due to the lack of attention. Another challenge that can be a restrictive factor for learning is the digital or technological equipment, or learning environment that is not optimal and functional for everyone. Only in the classroom, do all the students have the same learning conditions.

Regarding the suggested solutions for improvement of the teaching and learning practices, the focus-group members provided cohesive and creative answers. The ESP courses should be introduced in the third year of studies, or earlier, but for Spanish, they agreed that LSP could form part of the general Spanish course. Students support the introduction of the flipped classroom in a gradual way, starting from the beginning of their studies. They agreed that information should be accessible and clearly presented for all in the LMS university platform. The video lessons or presentation materials must not be long. Students would feel more encouraged for autonomous learning if their active participation is awarded (with additional points or other stimulative rewards). The participants also suggested a gradual transition from the traditional classroom to the flipped models, starting from the primary and secondary schools, but also a parallel implementation at universities, to make students more familiar with active and flipped learning.

6. PEDAGOGICAL IMPLICATION

Following based on previous findings here are some pedagogical implications of this research:

- The flipped classroom is an effective model within the hybrid learning methods and it can be applied in different courses and teaching subjects, including the LSP.
- The flipped learning ought to be implemented gradually, starting from the beginning of the course. Students need to be instructed in a clear way about all teaching and learning procedures but also provided with effective and meaningful tools and materials to learn actively and autonomously.
- The synchronous interaction: face-to-face or virtual teaching sessions in real time are essential, because they facilitate direct interaction among teachers and students, allowing teachers to keep

under control both aspects- learning progress and learning problems-, and enable them to act accordingly.

- Duration of the tasks and lessons: the video lessons, presentations, and tasks should be no longer than 15 minutes each, and accessible on the LMS university platform.
- Students reveal that they learn better when their progress and participation are awarded (with additional points or with other stimulative rewards). Helpful tools for that purpose are gamebased quizzes and tasks with feedback.
- Gradual transition: A step-by-step change from a traditional classroom to flipped learning should be implemented in both, lower and higher educational levels.
- LSP courses: The focus on specific terminology and determined communicative contexts are preferable for university classes. The language classes should be specifically oriented to the professional language context, which can be applied in various work environments.
- Challenges: Individual learning and self-teaching in online asynchronous mode might be challenging because of several reasons: lack of concentration and digital distraction, non-stimulative learning environments, technological issues y non-relevant learning material.

7. CONCLUSION

The study examined and identified benefits, drawbacks, and solutions for the flipped LSP learning model. On the one hand, it was based on existing teaching experiences and recent research papers, and on the other hand, it suggested selected digital tools to encourage active teaching and learning with the aim to improve learning outcomes in the hybrid and flipped learning environments. Finally, a conducted qualitative research illustrates the perception of students, potential learners of the flipped LSP courses. In conclusion, the creative and personalized use of digital tools in the flipped language for specific purposes can facilitate numerous advantages for both teachers and students. The asynchronous interaction can be beneficial for self-paced learning and self-teaching, offering flexibility and adaptable learning time management. However, synchronous teaching or face-to-face interaction in real time remains essential. In direct interaction, teachers and students are allowed to

have better control over both aspects-learning progress and learning difficulties, which enables them to examine and find creative solutions. By integrating flipped LSP learning, institutions can facilitate both active teaching and autonomous learning, promoting the development of competencies, regular assessment, and pleasant learning environments.

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INFORMATION TECHNOLOGY IN TEACHING FOREIGN LANGUAGES SESSION

USINGAI CHATBOTS IN ACADEMIA- THE OPINIONS OF UNIVERSITY STUDENTS

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Abstract:

The aim of this paper is to analyze the attitudes of students regarding the use of AI chatbots for academic purposes. The theoretical part of this paper offers an overview of previous theories, studies, and publications related to the use of ICT tools in education, the role of teachers in contemporary societies, and the goals of students in contemporary societies, as well as recent research on the use of A.I. in the public sphere, whereas the research part of the paper offers an original study conducted for the purpose of this conference. The research instrument was an online survey given to university students (78) with multiple types of questions, with the purpose of discovering whether our students were familiar with the concept of AI chatbots, had they ever used it, and, if so, for what purpose, and whether they would be willing to use it for academic purposes.

Keywords:

Al Chatbot, Academia, Educators, ChatGPT, Artificial Intelligence.

INTRODUCTION

The purpose of this paper is to gain early academic insight into what is and will, doubtlessly, continue to be, at the forefront of concerns for education, academia, and research work at all levels. The authors of this paper had first become aware of the public distribution of artificial intelligence software at the end of 2022 when one of them received a timed assignment from a student of an introductory course, which subconsciously raised several red flags. The essay did not excel due to its groundbreaking thesis statement, nor was it poorly written. Quite the oppositeit was a very formal, almost textbook-like paper, checking all the right boxes and fitting into the professor's requirements completely, with nary a grammar error or misspelling to be found. Why the alarm then? The problem lay in the fact that the student had not submitted a paper that had its full basis in the course materials, which had been diligently explained and provided to them throughout the semester. Although it is not uncommon, and is, in fact, encouraged that students expand their knowledge by seeking outside sources, the reality is that many, or rather, most of them, do not, particularly as first-year students who are just at the beginning of their tertiary academic careers.

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As news sites, journals, and conferences began updating the public about both the wonders and potentially hazardous consequences for creative and academic professionals, the authors were inspired to take a closer look at their own surroundings and uncover what they could about the still-early days of A.I. chatbot usage.

2. AI CHATBOTS

One of the most recent and pressing difficulties for educators and education officials is the use of advanced artificial intelligence (AI) technologies in learning environments. AI chatbots and other novel alternative Information and Communication Technologies (ICT) solutions are made possible by conversational AI, which stands to become a threat not only to academia, but to all manners of careers requiring higher education. Although the traditional teaching process, i.e., student-centered learning, is still the cornerstone of our educational systems, it seems it might be replaced by the newest technology, due to constant developments in the digital era. The teacher-centered method empowers students to simply receive knowledge from their teacher without building their commitment level. However, most lecturers are used to practicing the student-centered approach to encourage interest, analytical research, critical thinking, and feelings of fulfillment among students. [1]

According to Mageira et. al. [2], 'AI chatbots are intelligent systems/applications that are able to interact with humans in various aspects of daily life using natural language (NL). In the educational context, AI chatbots can play the role of intelligent tutors by presenting educational material, stimulating dialogue, providing feedback to students, etc. In some cases, AI chatbots can also play a complementary/supportive role to human tutors by answering students' questions and providing guidance in a 24/7 timespan, something that is evidently impossible or unprofitable to implement with human tutors.' According to the same authors, 'Chatbots can play an important role in the field of education because they are an interactive mechanism compared to traditional e-learning systems. Among other ICTs, chatbots are considered safe and accessible learning tools that can bring positive results in learning.' [4] Some other studies claim that, by accelerating response times and being accessible around-the-clock to answer or clarify any question, AI chatbots improve user-student satisfaction and, in this way, teachers can support students who have missed one or more lessons while avoiding answering repetitious inquiries that chatbots can quickly respond to. According to Hattie, a teacher typically does not have enough time during a lesson to provide formative feedback to each individual student. [5] However, formative feedback given to students during the learning process is one of the most crucial elements in raising their performance and motivation, and An AI chatbot has the capacity to help each student individually, using various learning pacing methods, and delivering knowledge in accordance with each student's unique cognitive level.

Even though the role of teachers has evolved, and teachers have now become facilitators, moderators and instructors, the technology used in education can act as a supplement, but not as a substitute for teachers. [6] Furthermore, according to Ilić and Bošković Marković, 'online teachers are more accountable for the production of their class materials and for the overall design of their classes, as they are quite often recorded and replayed by their students, or by the university management,' which also adds to the importance of teachers even in the digital era. [7] This is why we should also bear in mind the opinions of teachers. According to one previous study, 'although they state that they feel comfortable using ICT tools in their classroom and perceive new technology as a tool that contributes to better language acquisition of students, teachers also often or always apply the traditional methodology in the teaching practice, which shows that they consider benefits of innovative methodologies assisted with new technology, but do not discard the proven traditional formulas for effective teaching and learning.' [8] That being said, Daniel Lametti of Slate Magazine points out that 'chatGPT might fail at tests of reasoning, but it's great at generating human-like text to different lengths and in various styles,' [9], openly acknowledging the benefits of taking advantage of this new tool, in which a project requiring hours of research and writing could be whittled down to mere minutes, by simply inputting the required length, topic, and tone of the desired project. The Economist cites a March 2023 study, warning that "teachers, especially those of languages, literature and history, are next on the list," (in terms of occupations likely to be made redundant due to A.I.) [10] The same article, however, also recognizes that jobs that require basic human qualities, namely empathy and charisma, will not be able to be reproduced by A.I. [10]. At least not yet.

Taking all these things into consideration, we should not blindly succumb to the use of AI in all segments of higher education. To be more precise, we should choose wisely when it comes to the area in which this usage can or cannot be allowed. As digital pioneers, our students might hold different opinions. This is why we have decided to conduct a study in order to examine their thoughts, previous experiences, and especially their attitudes toward the use of AI chatbots for academic purposes.

3. RESEARCH METHODOLOGY

Since the goals of this study are primarily exploratory, an observational and correlational design was used in its implementation. The research was conducted on a convenient sample of 78 respondents, of which 49 selfidentified as male, 24 as female, and 1 preferred not to say (Figure 1). 65 participants declared themselves as Serbian nationals while 6 declared themselves as members of another nationality (Figure 1).

All participants were university students, with most of the first-year students (Table 1).

All the respondents applied to participate in the research, they were informed about the tasks in advance, that the data would be used exclusively anonymously,

and that, at any time, they could withdraw from the research without any consequences. The research was carried out in accordance with the Ethical Principles and Code prescribed by American Psychological Association (APA). All respondents were given an anonymous survey to fill out via the online platform Google Forms. The questionnaire consisted of two parts. The first part consisted of questions related to the socio-demographic status of the participants. The second part consisted of questions and statements related to the use of AI chatbots in an academic environment. The questionnaire consisted of 10 open-ended and closed-ended questions, as well as 3 questions to which the degree of agreement was expressed on the basis of a five-point Likert-type scale. After collection, in order to perform further analyses, the data were coded and transformed into a numerical matrix. The data from the questions of the survey were transformed into nominal and ordinal scales according to the respondents' answers and their frequency. Answers to the statements were converted to an overall average score ranging from extreme disagreement or negative attitude (1) to extreme agreement and approval (5). Based on the calculated scores descriptive statistical analyses as well as non-parametric analyses of variance (Kruskal-Wallis) were performed. Microsoft Excel 2007, SPSS 20 and Jamovi software package were used for performing the analyses



Figure 1 - Percentage representation of genders and nationality in the sample.

	1	0 1	
Levels	Counts	% of Total	Cumulative %
1^{st}	38	51.4 %	51.4 %
2^{nd}	11	14.9 %	66.2 %
3 rd	11	14.9 %	81.1 %
$4^{ m th}$	14	18.9 %	100.0 %

Table 1 -	Structure of	f the sample	according to	the year of	of study.

4. RESEARCH RESULT

To the question "Have you heard of AI chatbot, chatGPT, or other artificial intelligence programs?," 60 (81.1 %) of responders said "yes," while 14 (18.9 %) claimed "no." According to the frequency of answers to this question, there were no significant differences found between respondents of different genders, nationalities, or year of study.

This question was followed by the instruction "If no, end of the survey. If yes, continue," so that further analyses were performed on a sample of the 60 respondents who answered "yes" to the question concerning the existence of the AI chatbot.

To the open ended-question "To the best of your knowledge, when did you first hear about it?", most of the answers relate to the time frame of the second half of 2022 and the first half of 2023. It is interesting that even though it was not asked, the Tik-Tok platform was singled out as the main source of information in the answers to this question.

To the question "Have you ever used an AI chatbot just for fun?" 27 (45 %) of responders answered "yes," while 33 (45 %) claimed "no." According to the frequency of answers to this question, there were no significant differences found between respondents of different genders, nationalities, or years of study.

To the question "Would you ever use an AI chatbot for an academic assignment?" 16 (26.7 %) of responders answered "yes," while 44 (73.3 %) claimed "no." According to the frequency of answers to this question, there were no significant differences found between respondents of different gender, nationality and year of study.

Descriptive indicators of answers to questions: "Scale 1-5 (1-not conflicted, 5-most conflicted), how would you feel upon turning in a project/paper/assignment that you did not work on entirely on your own?"(9), "To the best of your knowledge, would your work be perceived as faulty by others?"(11), "Would you use AI chatbot to turn in an assignment?"(12) are shown in Table 2. According to the scores made from answers to these questions, there were no significant differences between respondents of different genders, nationalities, or years of study in any question.

The frequency of responses to the question of what the possible reason for would be using an AI chatbot for an academic assignment is shown in table 3, while the rest of the responders (21) claimed they wouldn't do so or didn't provide an answer.

1	1 -		
	9	11	12
N	59	58	60
Missing	1	2	0
Median	3.81	3.43	4.00
Standard deviation	1.07	1.29	1.31
Minimum	2	1	1
Maximum	5	5	5
Skewness	-0.218	-0.406	-1.02
Std. error skewness	0.311	0.314	0.309
Kurtosis	-1.33	-0.626	-0.258
Std. error kurtosis	0.613	0.618	0.608

Table 2 - Descriptive Statistical Analyses for Questions 9, 10, and 12.

Levels	Counts	% of Total
I do not know much or enough about the assignment to do a good job on my own	20	37.7 %
Because I am short on time	13	24.5%
I believe I'd do a better job than AI	1	1.9%
I didn't use it, somehow it really depends on the subject if you work something that you are interested in, you don't need these kinds of application, because you want to do these tasks with joy, however it can be a problem when people need to something they despise or simply because they are bad at this work, but I don't think this application can help you if you don't have self-criticism and primary knowledge on subject or essay you are working on [sic]	1	1.9%
I saw/heard other students do so, and felt they had an unfair advantage	1	1.9%
I wouldn't have a conflict, in case I used it for inspiration and to gather ideas. If it were completely written by AI and unaltered by my, I wouldn't turn in the assignment.	1	1.9%
The bot probably has more eloquent sentences and could fix my mistakes. Maybe even use it to paraphrase parts of my text if I struggle making it make sense. Maybe even use it as an example or a guide as to what exactly is expected of me.	1	1.9%
To make it more representable	1	1.9%

Table 3 - Frequency of the Reasons for Using AI chatbot for an Academic Assignment.

5. DISCUSSION

The most frequent responses to the question "What are your thoughts on the use of AI chatbot when it comes to academia?" were: "I do not know much or enough about the assignment to do a good enough job on my own," with over one-third of the respondents opting for this response, while over a quarter of the respondents chose 'Because I am short on time." To interpret the response "to make it more representable" is to assume that the respondent claims the AI software might be more capable of creating or finishing a more streamlined final product than they themselves might. Arguably, it is somewhat polemic to come across so many students responding with "I do not know much or enough about the assignment to do a good enough job on my own," as this implies that they do not deem themselves capable of submitting a project good enough of their own accord. Given that each incoming generation enters academia with more access to and better tools for research than the previous, the logical assumption would be that the students ought to feel empowered to create more and better work. Furthermore, most professors themselves consistently upgrade and improve upon their course materials, adapting to both the times and to their students, as is expected of an academic environment. As such, this is an issue that is ripe for future research. A more believable scenario would be to anticipate a lack of sufficient time being the reason behind opting for AI assistance, even as a last-minute resort. In this world with so many distractions and pulls in multiple directions, it would be unrealistic to assume that university students, most of whom are young and have grown up with the Internet their entire lives, would be spared. From doomscrolling to niche topics on various social media platforms to the fact that nearly all academic courses can be followed remotely-all this and more has contributed to a lack of attention span and the realization that time has unwittingly slipped us by. Coupled with the fact that many students, in addition to studying, are also working part or full-time, "because I am short on time" is not only a plausible, but an expected common answer. That being said, at least in these still early days of publiclyused AI software-and no doubt this Chimera will only continue to multiply its heads-it is encouraging to note the paucity of responses from students who-at least in this survey, which was an anonymous claim to harbor no conflict of interest towards utilizing it, or frustratingly opt for it because they feel their peers might have an unfair advantage.

6. CONCLUSION

This preliminary insight into (undergraduate) student experiences offers a humble yet intriguing firsthand perspective that should continue to be investigated, and frequently so, with each new generation of not only incoming students but following every additional upgrade to AI software made available to the public. Future steps should certainly include a breakdown of fields of study in which student reliance upon software technology is suspected or anticipated with a particular focus on the distribution between humanities/social sciences and natural sciences. It would be fascinating to compare with previous works based on problem-solving, academic analysis, or creative writing, and discover whether the human-made output stood out for its effort and final product, or whether the machine-produced result won out on all fronts.

Close attention should also be paid to improvement in AI detection software, and whether it will even be able to keep up with recognizing wholly newly produced material, which is the definition and goal of chat GPT and other tools. In a move similar to plagiarism-detection tools made available starting over twenty years ago, and as copyright infringement is rife in both technical and creative fields, it seems that opening Pandora's box of text generation will add an additional job to educators' already encumbered list of tasks by forcing them to question and check the veracity of each student assignment.

Finally, we as educators and professionals in the field must also face a rather daunting choice concerning our own opinions on AI software. Just as we no longer consider using calculators to be akin to cheating at math, and as every translator worth their salt is expected to use TRADOS (though, over the past decade, multiple free translation tools have also become available), has the time come for us to simply embrace the tired adage of 'work smarter, not harder?' We continuously tout our aims to pass on to our future leaders the importance of critical thinking, and how it is superior to rote memorization when it comes to education-can this task still be performed with a little help from the Internet? We shall wait for future studies to give us answers to this significant question.

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INFORMATION TECHNOLOGY IN TEACHING FOREIGN LANGUAGES SESSION

AMERICAN SIGN LANGUAGE ALPHABET RECOGNITION AND TRANSLATION

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Abstract:

This paper presents a study on American Sign Language (ASL) alphabet recognition and translation. ASL is a complex language used by the Deaf community for communication. With the increasing dependency on technology in our daily lives, and with the increasing adoption of working from home, the successful inclusion of these communities in video calls and meetings is of great importance. With great advancements in Artificial Intelligence over the past years, it has now become possible to build, train and use proven to be powerful image-processing convolutional neural networks (CNN) for successful sign language recognition and translation into English text. The models have been trained and tested on a University of Exeter-derived dataset and have achieved high accuracy in this task. We have compared the results of several pre-trained models using transfer learning, as well as our own CNN. Our study shows great possibilities for improving communication between the Deaf and hearing communities.

Keywords:

Convolutional Neural Network, Image processing, Transfer learning, American Sign Language.

INTRODUCTION

Expanding on the assistive technologies present today is more important than ever before. Recent world events have increased our dependency on technology and have pushed many into a new way of working from home. To give every community, and every person an equal chance of successfully navigating this new way of living, assistive technology advancements must continue.

We have embarked in this study upon a challenge of recognizing and translating American Sign Language (ASL), which is a natural language that is utilized by individuals who are deaf or hard of hearing in the United States and other parts of the globe. Despite being a complex and expressive language, the fact that not everyone is proficient in ASL presents unique communication and interaction challenges with those who are hearing. Recent advances in Machine Learning and the proven ability of Convolutional Neural Networks to classify images more and more accurately have made it possible to develop systems that can recognize and translate American Sign Language in real-time.

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Sign language in general relies of course on static signs but as well on movement and hand position. Successful translation and recognition of ASL consists of training the model on a large dataset of hand signs and gestures. In this study, we will be translating only static signs. The reason behind this is that we have made use of a dataset that consists only of images, therefore the study conducted focuses on static signs of ASL alphabet letters. The focus is on successfully classifying and translating 24 letters of the alphabet A-I, K-Y. Letters J and Z have been excluded from the classification as movement is required for their representation [1]. Letters P & K, as well as Q & G, use the same sign but in a different position, but as the distinction can be made in the dataset for these sets of letters, the images that represent these letters have been placed in their respectable classifications.

CNNs are a class of deep learning algorithms that can be applied to a wide range of image classification, object recognition as well as facial recognition tasks. They can either be created from the beginning or pretrained CNNs can be used that have been created already by large organizations.

This concept of using someone else's neural network is called "Transfer learning" [2]. The main reason behind transfer learning is that the actual training of convolutional neural networks requires a lot of resources and a lot of data. Therefore, organizations with access to greater computing power and data build and train complex models that otherwise could not have been able to be made by any individual and let other people use their models for their purposes. Transfer learning models are made to be as general as possible within image classification in this case, so that they can be applied to any problem. The borrowed models can be tested on the dataset to which our problem is related and if needed certain parts and weights of the borrowed model can be adjusted to fit our dataset better. It is important to limit the amount of re-training allowed so we don't completely diminish the current weightings created by extensive training on large datasets, otherwise, transfer learning models will lose their value. It is also possible to add extra layers of our own on top of the pre-trained model. In this study, we have made use of both approaches.

We have created a CNN from the beginning and have used pre-trained models such as ResNet50, MobileNetV2, and VGG19. ResNet50 is a 50-layer convolutional neural network consisting of 48 convolutional layers, one Max Pool layer, and one average pool layer [3]. The MobileNet-v2 is a convolutional neural network that has 53 layers and has undergone extensive training using a vast ImageNet database. This pre-trained network is capable of categorizing images into 1000 distinct object categories, including animals, pencils, keyboards, mice, and more [4]. VGG19 is a convolutional neural network that has 19 layers and has also been trained on the ImageNet database, capable of classifying images into 1000 categories [5]. We have added several extra Dropout, Dense, and Batch Normalization layers to all the transfer learning models mentioned above. In this paper, we will examine the architecture of the models used, training and testing principles, and performance. We will also discuss current limitations and future directions for improvement.

2. DATASET

The dataset itself has been derived from the University of Exeter's [6] website. It consists of 55,000 images. The images have been preprocessed into a 160x160 format with 3 color channels and have been split into two subsets. Training and test. Inside every subset, there is a folder for every classification of images. The class names have been transformed from categorical to numerical. A few data samples with their respective categorical classifications can be seen in Figure 1.



Figure 1 - Sample images from the dataset with their classification included.



Figure 2 - Data augmentation example

Since the dataset is not very large and diversified, to decrease overfitting as much as possible we have used Data augmentation techniques such as Random Zoom, Random Flip, and Random Rotation. An example of the result of this technique on a single image can be seen in Figure 2.

3. APPLIED METHODS AND ARCHITECTURES OF CONVOLUTIONAL NEURAL NETWORKS.

The CNNs can have an array of different kinds of layers within them. We will explain shortly what each of the layers we have used in the study are used for:

- The fundamental building block of a CNN is the convolutional layer. It contains a set of filters and parameters which are learned through the process of training. The filters convolve over the images and the dot product of the filter and the underlying pixel values is calculated at every position. After this operation has been done for the entire image, the feature map or input for the next layer has been formed [7];
- Pooling layers are usually placed right after convolutional layers since they provide an approach to down-sampling feature maps. Therefore, they reduce the number of parameters a network needs to learn, and the amount of computation performed in the network. The pooling layer summarizes the features present in a certain region of the feature map that has been generated

by the convolutional layer. This makes the model more robust to variations in the position of the features in a given image. There are two types of pooling techniques. Max pooling involves identifying the maximum value element within a specific area of the feature map that is encompassed by the filter. The output is then a feature map that contains all the most prominent features of the previous feature map. There is one other technique of pooling, which is Average pooling. It calculates the average value of the elements present in the region of the feature map with the averages from each region [7];

- The dropout layer is responsible for randomly selecting a given number of neurons to ignore during training. This is most frequently done to reduce the effects of over-fitting;
- The flattening layer converts the data into a 1-dimensional array for input into the next layer; and
- A dense layer, as with any other neural network, establishes a deep connection with the preceding layer by interconnecting the neurons of the layer with each neuron of the preceding layer.

3.1. CUSTOM CONVOLUTIONAL NEURAL NETWORK

We have implemented our neural network using TensorFlow's Keras API. The network itself consists of three convolutional layers, three max-pooling layers, two dropout layers, and two dense layers. The model takes the input images and outputs a classification prediction for one of the 24 classes. Here is a brief description of the layers in the model:

- 1. Data augmentation: The first layer of the network is a data augmentation layer, which applies the previously mentioned augmentation techniques to images to increase the size of the training dataset;
- 2. Rescaling: This layer rescales the input pixel values from a range of [0, 255] to [0, 1];
- Conv2D: This layer performs convolution on the input image using a set of learnable filters. The layer has 16 filters, a filter size of 3x3, and a ReLU activation function. Padding has been used to preserve the images in 160x160 format;
- 4. MaxPooling2D: This layer downsamples the feature maps produced by the convolutional layer;
- Conv2D: This layer performs convolution on the output of the previous MaxPooling2D layer. This layer has 64 filters, a filter size of 3x3, and a ReLU activation function. We have again used padding to preserve the image dimensions;
- MaxPooling2D: Just like in the previous max pooling layer, this layer downsamples the feature maps of the convolutional layer and produces a feature map of the strongest features;
- Dropout: This layer randomly drops out some of the features during training to reduce overfitting. We have found in this case that a figure of 50% works best;
- Conv2D: This is the last convolutional layer in the network. It has 64 filters, a size of 3x3, and a ReLU activation function. No padding has been used in this layer;
- 9. MaxPooling2D: This is the last max pooling layer, producing the final feature map that will be used for classification;
- Dropout: We have again decided to include an aggressive dropout layer with a 60% dropout rate due to the problem of overfitting;
- 11. Flatten: This layer flattens the output of the previous MaxPooling2D layer to create a 1-Dimensional vector.
- 12. Dense: This fully connected layer has 128 units and a ReLU activation function. It applies L2 regularization with a coefficient of 0.01 to the activity of the layer; and

13. Dense: This fully connected layer has 24 units and no activation function. It produces the final classification output.

The optimizer used during training is RMSProp. The learning rate used in this model is 2e-5, a small value has been used to ensure that the model parameters are updated slowly during training to improve model convergence. Callback has also been used to train this model with a monitor for validation loss. The model has been trained in 50 epochs with a batch size of 128.

3.2. PRE-TRAINED MODELS

The pre-trained models used in this study are VGG19, ResNet50, and MobileNetV2. Let us go over our implementations of each of them. A general approach that we have found to produce the best results is to only include the base of the pre-trained model and our own dense and classification layers.

3.2.1. VGG19

The VGG19 implementation in this study includes the base model as well as 8 additional layers.

The first additional layer after the base model is a flattening layer, that creates a 1-dimensional array of the base model's output. A Dense layer follows with 512 units and a ReLU activation function. We have then used a dropout layer with a rate of 40%, a batch normalization layer, another Dense layer with 512 units, and a ReLU activation function followed by a dropout layer with a rate of 50% and a batch normalization layer one more time. The final layer is a dense layer with 25 units, using a SoftMax activation function and an L2 regularizer with a coefficient of 0.01. The model has been trained with the use of an RMSProp optimizer with a learning rate of 1e-5 with a Sparse Categorical Cross entropy loss function.

3.2.2. Mobile Net V2

The Mobile Net architecture has been used without its top layers, and the trainable parameter has also been set to False, which freezes the weights of the pre-trained layers in the Mobile Net to avoid overfitting. We have also used the techniques of data augmentation as well as preprocessed the input using the pre-defined Mobile Net pre-processing function which scales the pixel values from [0, 255] to [-1, 1]. Just like in the case with VGG19, after the base model output we have implemented a flattening layer followed by a dense layer with 512 units and a ReLU activation function. Followed by a dropout layer with a rate of 50%, a dense layer with the same configuration, another aggressive dropout layer with a rate of 70%, followed by the last and dense layer with 24 units, SoftMax activation, and L2 regularizer with a coefficient of 0.01. The model has been trained using the RMSProp optimizer with a learning rate of 1e-5 with a validation loss callback function. It has been trained in 25 epochs with a batch size of 128.

3.2.3. ResNet 50

For the implementation of the ResNet architecture, we have set the trainable attribute to True, allowing the whole model to adapt during training. As well as for previous models the first layers are for data augmentation and scaling. Scaling has been done the same as for Mobile Net with pixel values ranging from -1 to 1. Then the input will go through the base ResNet model. The additional 8 layers are similar to the previous models, with the first being the flattening layer, followed by a 512-unit dense layer with the ReLU activation function, a dropout layer with a rate of 50%, batch normalization, another identical dense layer, dropout layer with a rate of 70%, batch normalization layer and the last layer being the dense layer with 24 units, SoftMax activation and L2 regularizer with the coefficient of 0.01. This model has been trained with the Adam optimizer with a learning rate of 1e-5 with a Sparse categorical cross-entropy loss function measuring accuracy, and a callback validation loss function.

4. RESULTS

We have measured the training and test accuracy of our models. We have as well measured the training and validation loss. Here we will discuss the results obtained from each of the models used and compare them among the models. A figure showing the training and validation curves will be shown for every model.

Let us begin by showing the results of our neural network. As can be seen in Figure 3, the training accuracy is reasonably high at 89.53% and training loss has become very low by the 50th epoch. We can conclude that as the number of epochs rose the training accuracy and training loss have become better and better. Unfortunately, the opposite can be said for validation loss and validation accuracy. The model has achieved a validation accuracy of a mere 67.03%. During the first 20 epochs, the validation accuracy and validation loss have exponentially gotten better, but after that point, the progress slows down rapidly, and very little progress is made by the 50th epoch.



Figure 3 – Training and validation results of the custom-made CNN.

316

Let us see now how the transfer learning models have performed. We shall first look at the Mobile Net model. As can be seen in Figure 4, the training accuracy achieved is 83.07% and has progressed rapidly with every epoch. Test accuracy however is very low with only 51.64% accuracy. We can see a sharp decline in learning progress by the 5th epoch and by the time all the epochs have been done, no significant progress has been made.



Figure 4 – Training and validation results of the MobileNetV2 model.

The following model results we shall discuss are of the ResNet model. As can be seen in Figure 5, the training accuracy quickly peaks at 99.92%, training loss is also very low. Validation accuracy jumps by 10% in the first 2 epochs, but it takes 8 epochs more for it to go 7 percentage points higher, capping at 86.87% accuracy. The validation loss has not gotten any better after the second epoch.

The last transfer learning model, the VGG19 has been trained in 3 epochs. As we can see in Figure 4, the model has large jumps in both training and validation accuracy for every epoch, but the validation accuracy curve quickly loses its momentum. The model achieved a training accuracy of 97.66% and a validation accuracy of 87.56%.

As we can see from the results above, the VGG19 network has the best validation accuracy of all the models used in the study. We also find it interesting that our network has outperformed the Mobile Net V2 model, which has also the worst validation accuracy at only 51.64%. An important thing that can be seen from the figures above is that the problem of overfitting is very prominent for all the models, despite the efforts of data augmentation, the dataset is simply too small to completely overcome overfitting.



Figure 5 – Training and validation results of the ResNet50 model.



Figure 6 - Training and validation results of the VGG19 model.

5. CONCLUSION

We have seen in this study great possibilities of one day translating the entire American Sign Language. The models we have used and created have proven to be very good at successfully recognizing ASL signs with the highest accuracy we have achieved being 87.56%. A continuation of this research is required to achieve even better results. The most important piece missing in this study was a good dataset. Results can be drastically improved with a better and bigger dataset, as that would solve the biggest challenge we have faced, which is the problem of overfitting. A better dataset that would also include videos, so neural network models can be trained on gestures would be just as important. Nevertheless, convolutional neural networks have proven once again how powerful they are and the limitless number of possibilities that can be achieved with them.

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INFORMATION TECHNOLOGY IN TEACHING FOREIGN LANGUAGES SESSION

TEACHERS' PERCEPTIONS OF ICT IN POST-PANDEMIC FOREIGN LANGUAGE TEACHING AT THE TERTIARY LEVEL IN SERBIA

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Abstract:

Having reshaped the landscape of (foreign language) education, it is argued that the COVID-19 pandemic did introduce certain modifications that were seen as potentially positive in the long run. Therefore, acquired knowledge about ICT and its application in teaching as well as learning, can be considered a meaningful asset for the present and future of education. On this occasion, the focus of the paper is set on foreign language teachers working at the tertiary level and their perceptions of ICT as a beneficial instrument in the post-pandemic context in Serbia. To be more precise, the opinions of 83 teachers have been collected through an anonymous questionnaire, containing twelve multiple questions considering their experience with ICT before, during, and after the pandemic. Based on the quantitative data gathered through the responses, a significant number of them have used and thus still frequently use digital tools in their classes, whilst believing that digital skills and the awareness of its usage during the pandemic are of great importance. The qualitative method component has been introduced by leaving the opportunity for the respondents to add their own answers to every posed question. It was noted that some of the examinees emphasized that their choice to make ICT an integral part of their classes (online or in person) is not related to the period of the pandemic, but a conscious decision to learn and develop themselves independently of the external factors, that is, the pandemic, the institution where they work or any others.

Keywords:

Foreign Language Teaching, ICT, Teacher's role, Tertiary Level.

INTRODUCTION

Even though the COVID-19 pandemic did reshape the (formal) educational system worldwide [1] [2] [3] [4], new perspectives on teaching in general, and foreign language teaching in particular that were acquired accordingly, cannot be disregarded. For that reason, in light of the postpandemic period, it is only natural to wonder If and how the education landscape will be altered [1]. Therefore, teaching foreign languages at the university level in Serbia was also expected to inevitably go through the same adjustments which meant that, consequently, traditional teaching methods needed to be put aside for the epidemiological situation dictated so.

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Although nowadays it seems that ICT (Information and Communication Technology¹) is almost a necessary asset in (foreign language) teaching [4], it is argued whether it has the supposed role and impacts on learning due to the lack of strong empirical evidence [1] [5]. On the other hand, it is not the same to have a choice to use digital tools to enhance performance in the classroom and to be forced to (learn how to) use them [3] [6]. Moreover, it is necessary to use them purposely and intentionally, as an integral part of the teaching method applied [5] [7].

2. THE ICT IN (FOREIGN LANGUAGE) TEACHING IN THE PANDEMIC AND POST-PANDEMIC ERA

According to [8], "the digital revolution that is sweeping the world has begun to infiltrate the realm of education", whilst [7] claims that ICT has great potential and thus will continue to transform the world in ways that were not thought possible. However, [3] reminds us that, even though ICT in foreign language teaching is a concept that has been present and updated over the years, it has never happened before that the whole educational system must switch to an online environment at once, which led to its increased presence and pointed out crucial importance [2]. With that in mind, it must also be said that the migration from in-person classes to a fully online environment at the time wasn't an easy transition for the teachers or the students.

The possible issues for both (online) classroom participants, meaning teachers and students, was the lack of pre-preparation [1] [2] [6] and, on some occasions, not sufficient level of digital literacy [9] and with it, less motivation and, thus, willingness to motivate students, considering, of course, the (lack of) technical equipment available to them [1] [2]. These shortcomings can reflect in the moment of the necessary change, considering the rather specific circumstances, and because of it, the teachers didn't receive any previous training [8] [10]. But it is also important to take into account the absence of awareness about digital tools that can have an instructional role in the classroom, both online and in-person [11]. That itself implies, on one hand, the necessity of proper teacher training, not only in the means of how to use certain tools, but also to encourage the teachers to focus on how ICT can influence teaching and, thus, learning [7]. Likewise, it should be clear whether these tools are considered a means of necessity or assistance in teaching, and it shouldn't confuse one with the other [10].

In general terms, but especially during the pandemic, the teachers' role in the application of ICT, therefore, is of great importance, having in mind that, based on [12], it is the university who should motivate and engage the students to learn, and one of the ways to do it is exactly by using ICT. Thus, the overall doubt is not whether to use, but why and how to use it, as [7] specifies. Furthermore, in order to improve the quality of teaching, digital skills are an important prerequisite [13], primarily referring to the possibilities that using a certain digital tool has and the objective that it brings along [2] [5], even the possibility to combine the aspects from traditional and modern teaching approach, i.e., the "synchronous and asynchronous" [9]. Therefore, teachers' own attitudes, perceptions, and opinions are correlated with the degree to which the digital tools will be applied in the classroom [14].

In the digital era, the idea of a teacher as a leader and a central figure in the (online) classroom has shifted its direction to the student, while the teacher becomes the moderator, facilitator, and instructor [13]. As a result, the teacher assumes the responsibility of meeting the students' requirements [6] so as to favor language learning. Based on quite the amount of conducted empirical research so far in Serbia, [2] [3] [4] [6] [9] [11] [13] [14], students do mostly welcome the usage of ICT before and during the pandemic at different university contexts, confirming the previous idea of teachers having the different role than before, i.e. to recognize the students' needs. The question left to answer is whether the teachers still continuously use ICT and what are their perceptions accordingly.

3. RESEARCH

Since the pandemic's inception, as aforementioned, the focus of academic research in the area of (foreign language) education was mainly on correctly incorporating ICT into teaching and making it comprehensible and viable for all learners. With the pandemic coming to an end in Serbia², and the academic year 2022-2023 being the first organized without the legitimate need to use digital tools in the face-to-face classroom context, this paper aims to draw attention to the post-pandemic context.

¹ https://learningportal.iiep.unesco.org/en/glossary/information-and-communication-technologies-ict

² The COVID-19 outbreak is still ongoing in Serbia on May 13, 2023., but the situation is stable and thus there is no need for online teaching at universities. The expressions "postpandemic context" or "after the pandemic" are used in the sense that teaching is primarily done in person. https:// covid19.rs/homepage-english/

With that in mind, the objective of presenting the findings based on the teachers' answers relies on the assumption that university foreign language teachers still do use digital tools in their classes in Serbia, whilst understanding that there is still no concrete (published) research done to confirm so.

The investigation was, thus, thought with the intention to investigate teachers' choices regarding the programs they used and still use to communicate with their students and to give lessons with or without additional digital tools after the pandemic. Though ICT is, for some foreign language teachers, as previously mentioned, a well-known and useful instrument that they employ according to their (and students') needs, it is not always the case, as the investigation will show. Having in mind that, during the pandemic, however, using ICTs wasn't optional, and, therefore, all teaching practices had to migrate online. The result was an increased resort to ICT while the initial pandemic period lasted, with not that much data on how the teachers would address its importance afterward. With that in mind, the inquiry contained short and concise questions that can offer an insight into the current situation.

3.1. METHODOLOGY

The research itself has been conducted through an anonymous questionnaire distributed online. Prepandemic and post-pandemic foreign language teachers' routines for giving (online) lessons, that is, on ICT they were and still are using, were investigated through twelve multiple questions. The results were gathered based on the quantitative analysis performed on their answers to twelve multiple-choice questions. In addition, the qualitative component of the research was carried out through the interpretation of the responses added by the respondents on occasions when they wanted to emphasize a certain answer or include an option or an idea that wasn't foreseen by the questionnaire.

3.2. RESPONDENTS

University foreign language teachers were chosen to contribute to this investigation, having in mind that they are the ones who promote the usage of ICT and, accordingly, decide whether certain tools will be used and how. The hypothesis, as aforementioned, revolves around the supposition that most respondents employ the same tools as they did before the pandemic, i.e., the ones that were already considered familiar and demonstrated good results, with the additional theory that some may have incorporated the tools they learned how to do use during the pandemic.

Between them, three groups were identified: teachers who teach at a faculty of philological orientation (main foreign language course) that present more than half of the examinees (50. 8% = 43), teachers who teach at a faculty of philological orientation (elective foreign language course) with as many as 6% (N=5) and the ones who teach a foreign language at faculties of non-philological orientation (39.7% = 31).

When it comes to foreign languages that the respondents teach, English teachers hold the majority with 41%, whilst the Spanish language is taught by 19% of the teachers. German and French teachers follow, with 12% and 10%, and then there are Italian (4.8%=4) and Russian (2.4=2) teachers. Those being the six foreign languages most taught in Serbian formal education, it seemed appropriate to emphasize the fact that those teachers were the pre-thought examinees. The results can also be seen in Table 1.

Naturally, not all the respondents possess the same professional teaching experience. Whilst the highest percentage (40.1%=34) states to have worked between 10 and 20 years in the field of education, almost one quarter (24.1%=20) has more than 20 years of experience. A little over one-fifth of them (21.7%=18) has five to ten years of experience. The lowest number (13.3%=11) presented between one and five years of experience.

Foreign language	Number	Percentage
English	34	41%
Spanish	19	22.9%
German	12	14.5%
French	10	12%
Italian	4	4.8%
Russian	2	2.4%

Table 1 - Overview of the Foreign language taught.

3.3. FINDINGS

When it comes to teachers' perceptions of ICT usage, the initial interest revolves around the means of communication between the students and the teachers. Moodle platform and email were the primary two listed out of the five offered. Google Classroom and Microsoft Teams were the next two to follow, whilst Viber groups were the least used. The respondents added other programs that they used, mostly Zoom (13 of them), but also Google Meet (2), Webex platform (2), or Skype. It is presumed those were used to give lectures, not just for communication. Moreover, the examinees also introduced Facebook itself and Facebook groups or WhatsApp groups, Telegram, and Trello, but those are all named one time. The following question tries to analyze how communication is handled in the present. Table 2 is showing the comparison of platforms/programs used before and after the pandemic, and it is noticeable that every other means of communication was used less in the post-pandemic period except for the email correspondence, which indicates to be around 5% more used. Besides that, 15 examinees have added the option in person, that is, in class. Other channels were pointed out as well, Zoom platform (3), Facebook groups (3), WhatsApp (2), and social media, Google Classroom, and Telegram were mentioned one time.

Exclusively for the purpose of giving online classes, the Zoom platform was the respondents' primary choice with 43 of them (51.8%) confirming so. Two of them noted that they used Zoom with Google Meet or Microsoft Teams, that were also two other most-voted platforms: Google Classroom with 21.7% (18) and Microsoft Teams with 14.5% (12). Big Blue Button (3) and Webex platform (2) were also pointed out in the additional answers, as well as Moodle (2) and Skype (1).

When asked to affirm whether they work online, it turns out that 63.9%, i.e., 53 out of 83 teachers nowadays give lessons in the classroom, 22.9% (19) give online lessons but not at the university, and 6% (5) emphasize to have done it before the pandemic also. What remains are 9.6% (8) that confirm the university allows online lessons or some number of classes online, and the 6% (5) who teach fully online. Teachers also remark to giving online lessons only in case of need, an illness, or to organize tutoring hours for Master and Ph.D. students, whilst one teacher pointed out that the classes are online, but the materials are uploaded to Moodle and the other mentioned that the classes too are online, with the emphasis that material and tests are online so that students spend more time working online than in person.

Table 2 - The comparison of the platforms/programs used before and after the pandemic.			
Platform / Program	Before	After	
Moodle platform	61.4%	54.2%	
Google Classroom	28.9%	18.1%	
Microsoft Teams	19.3%	13.3%	
Email	67.5%	72.3%	
Viber group	4.8%	3.6%	

C C			
Number	Percentage		
73	88%		
49	59%		
28	33.7%		
22	26.5%		
19	22.9%		
15	18.1%		
11	13.3%		
11	13.3%		
2	2.4%		
	Number 73 49 28 22 19 15 11 11 2 2		

Table 3 - TThe digital tools used in online classes.

Concerning the other digital tools used for educational purposes, the respondents have shown great awareness of the websites and programs offered, as well as added quite more themselves. The results of an open multiple-choice question can be seen in Table 3. Most of the teachers do use PowerPoint and Google Docs, but JamBoard not as much, which is a board tool in Google Meet they did mention using. When it comes to gamification tools, one-third use Quizlet and Kahoot, while Quizziz is slightly less used. WordWall.net and LearingApps.org, the two websites where it is possible to create personalized exercises were marked as used respectively by 15 and 11 teachers. Mentimeter, a tool mostly used to give anonymous opinions or to make a word cloud to brainstorm an idea, was remarked by 19 teachers. Besides the programs and websites listed in the Table below, the respondents also added Miro (3), YouTube (2), Genial.ly (2), Padlet, Typeform, Zumpad, all options that Moodle has, Brainscape, Map.kits.blog, Pocker wheel, Wortwolken, Puzzlemaker, Stadtlandfluss, Story dice (story cubes digital), Bitpaper, Chat GPT, Flinga, Conceptboard³. Three teachers state to not have used any of the listed, nor have they added some that they do use. After verifying, it is found very peculiar that the three teachers have 5-10, 10-20, and over 20 years of experience and they teach different foreign languages at different types of institutions.

When asked whether they employed the aforementioned websites and programs before the pandemic, the majority state to have done it, but not as much (57.8=48), whilst the third (28.9%=24) claim to have used them frequently. The last option given was chosen by 5% (6) of teachers, noting that digital tools were not used at all, as though they are traditionalists. One teacher highlighted that during the pandemic, after attending a couple of seminars and receiving the right training, it was easier to start using more innovative tools, not just PowerPoint and some interactive websites. The other admitted to having started working at the university only during the pandemic, while another claimed to have used short films mostly. There are a couple of other additional answers, where one remarked on the traditional way of teaching, but the other two draw attention to the high frequency of implementing digital tools in their classes regularly, or in the same manner as before the pandemic, i.e., before 2020.

Before the COVID-19 outbreak, 61.4% (51) of foreign language teachers were familiar with some of the digital tools, whilst 25.3% (21) were familiar with them and have used them before, leaving 8.4% (7) who were also familiar with the tools but haven't used them and only 2.4% (2) who just started using them during the pandemic. One additional answer placed an emphasis on the individual pursuit to discover and employ digital tools in one's classroom.

Post-pandemic period poses an important question: whether the knowledge acquired through learning and adjusting to online classes was found useful and employable for the period after the teachers went back to the classrooms. On this occasion, 66.3% (55) of teachers state that it was very useful, even though 25.3% (21) claim to be relieved by not having to use them all the time. Moreover, 3.6% (3) believe that their way of teaching was better, and 2.4% (2) are not convinced that the acquired knowledge was useful for them. One of the additional responses points out again that the decision and willingness to use digital tools are not related to the pandemic, whilst the other one is, after confirming that every type of newly attained knowledge can have an impact on a person, but still wondering will it be used and how.

The final question remains to show if the teachers still do use digital tools in their classes, no matter if online or in person. The same number of teachers (31.3%=26) stated that they can't imagine their classes without them, but also that they use only the ones they have already used before the pandemic, whilst 20.5% (17) use them only if necessary. Between the additional answers mostly one main idea is shown: teachers do use digital tools, the ones they are familiar with, but also include, based on the type of class or unit that they teach, newly discovered ones.

3.4. DISCUSSION

Having presented the findings of the online questionnaire, it is shown that, as the hypothesis suggested, foreign language university teachers do still, in fact, use the digital tools they had employed before the pandemic, with a smaller number of those who have started using them more during and afterward. The traditional way of teaching is still present among the respondents, with some realizing that the fact they don't have to use ICT in their classroom is a relief. On the other hand, some stated to have been single-handedly introducing digital tools into their teaching, independently of their modality of teaching, and institutions' requirements.

³ All the names of the programs/websites used were listed in the order received because they were all mentioned one time.

Nevertheless, the sample acquired was found heterogeneous in terms of years of experience and also in languages taught. English teachers do present the majority, but it is believed that they are the most numerous in general, and at the tertiary level in particular. On the contrary, Russian and Italian teachers were, on this occasion, truly seen as a minority. Considering teaching experience, the lowest number presented the teachers with 5 to 10 years, while most teachers possess between 10 and 20 years.

When it comes to means of communication with students, the teachers have presented unanimity in decreasing the usage of channels other than email correspondence after the pandemic, even though all are still actively used. It was also shown that they possess diverse experiences in employing ICT in their classes, as a wide variety of different websites and tools was presented.

To narrow down, the number of teachers who presented only traditionalist views on foreign language teaching is less or equal to 5%.

4. CONCLUSION

This paper aims to present the university foreign language teachers' perceptions whilst using ICT in the post-pandemic period. It is thought that the COVID-19 pandemic could have left certain habits relating to the usage of digital tools that were merely mandatory while it lasted. The objective is to ensure how and do the teachers include them in their curriculums when there is no obligation to do so.

Even though for some of the enquired teachers pandemic ending was a relief, not only regarding the health issues but also the possibility of choosing whether or not they will use ICT in their classes, for one-third of them is almost impossible to imagine their lectures without it. Furthermore, it is encouraging that teachers themselves felt the need to add their perspectives and point out that they use the digital tools the same as before the pandemic, or irrelevantly to the pandemic itself, wanting to learn and develop their skills and classes. Showing awareness of digital tools that were presented in the questions, but also from their own experience is of great importance for the future of (foreign language) teaching, meaning that it could be said and concluded that the pandemic partially brought something positive to the Serbian high education landscape.

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Welcome to Sinteza 2023, the 10th jubilee conference on Information Technology, Computer Science, and Data Science, hosted by Singidunum University in Belgrade, Serbia. This international scientific conference will be held on May 27th, 2023. We are excited to bring together experts and professionals from around the world to share their knowledge and insights on the latest developments in these fields.

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